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INSECT LIFE

SOUVENIRS OF A NATURALIST

J.-H. FABRE

DOCTEUR ES SCIENCES

'that inimitable observer.'—CHARLES DARWIN

TRANSLATED FROM THE FRENCH

BY THE

AUTHOR OF 'MADEMOISELLE MORI'

WITH A PREFACE BY

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To the attentive eye the sight of industrial insects exhibiting the most refined art in their labours is a spectacle both strange and sublime. Human Reason is confounded by Instinct thus raised to the highest pitch of which Nature can offer an example, and the perturbation of intelligence increases on observing, patiently and minutely, the details of the life of those creatures most highly endowed with instinct.

E. BLANCHARD.

PREFACE

THIS little volume introduces the work of a great French naturalist to the reader of English. Réaumur, another Frenchman, is the greatest naturalist devoting himself to the observation of insects the world has yet seen. His six quarto volumes—*Mémoires pour servir à l'histoire des insectes*—were published between 1734 and 1742. J.-H. Fabre, who happily is still with us, is second only to Réaumur in this part of the great field of Natural History.

Though compatriots the two men are remarkably different in the nature of their genius. Réaumur, stately and slow, both discursive and diffuse. Fabre,—styled by Charles Darwin the immortal Fabre,—a most patient, indefatigable observer, ready to sacrifice everything to the carrying on of his work, but making deductions too rapidly from his observations, and taking a philosophical position from which he refuses to budge, even though he stand alone among the naturalists of this generation.

Fabre's great merit is his graphic portraiture of the living insect as it really is. This proves to be

very different from insect life as it is usually supposed to be by the uninstructed, and as it is only too frequently represented to be in books. In the volume now offered to the reader he is almost entirely concerned with the instinct of Hymenoptera, the highest of the insect world in this respect. His studies of this subject have been continued in several other volumes, and he has also included in the series the results of many years of observation of the habits of other and very different insects.

His philosophical position may be briefly stated to be a determined refusal to recognise evolution as a legitimate idea. In this we may think him wrong; but it must be admitted that his views form a valuable antithesis to those of the many evolutionists who take the position that all that remains for the naturalist to do is to repeat the words Natural Selection and variation, and declare that thereby we understand the Cosmos.

Fabre is a difficult writer to translate. Probably no one has ever written on this subject with equal brilliancy and vivacity. But he is the most Gallic of Frenchmen. If his words are literally translated they scarcely make English; if freely translated, the charm of his diction is too easily missed.

We hope that this volume may induce the student to read Fabre's subsequent volumes.¹ Taken

¹ *Souvenirs Entomologiques* (Ch. Delagrave, 15 Rue Soufflot, Paris), of which there are now seven series, this volume being a translation of the first.

PREFACE

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altogether they are, if not superior, at least not inferior to this one—preferred simply because it is the first of the series.

In his works there is a good deal of delightful autobiography. Starting as a child amidst the direst poverty, he has become a highly accomplished man, a great naturalist, a brilliant writer; and he has done this with a complete contempt for money, and a great indifference to the other rewards that Society is ready to bestow for such work.

D. SHARP.

CAMBRIDGE, *20th August* 1901.

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I

THE SACRED BEETLE

THIS was how it came about. We were five or six, I the oldest and their professor, still more their comrade and friend ; they, young fellows with warm hearts and lively imaginations, overflowing with that youthful vitality which makes one so open to impressions and so eager for knowledge.

Talking of one thing and another we followed a path bordered with elder and hawthorn, where already the Rose Beetle was revelling in the overwhelming scent of the clustering blossoms. We were going to see if the Sacred Scarabæus had yet appeared on the sandy plateau of Les Angles, rolling the ball of dung which ancient Egypt looked on as emblematic of the world ; we wanted to discover whether the running stream at the bottom of the hill might not hide young newts under the net of water weeds—newts whose branchiæ look like tiny sprays of coral ; to see if that elegant little fish of the rivulet, the stickleback, had donned his wedding cravat of azure and purple ; if the new-come swallows were

dipping on pointed wings over the meadows chasing the midges which scatter their eggs in their airy dance; to see if the Eyed Lizard was sunning his blue-spotted body at the mouth of a hole made in the sandstone; or if the flocks of Laughing Gulls, come up from the sea after the legions of fish which ascend the Rhône to spawn, were hovering over the river, and now and again uttering their cry like the laugh of a maniac. But enough; suffice it to say that, like simple folk who find much pleasure in living with the brute creation, we were intending to spend a morning in enjoying the ineffable awakening of life in springtime.

We were not disappointed. The stickleback was in full dress, his scales would have made silver look dim; his throat was of the brightest vermilion. On the approach of a great horse-leech with no good intentions, up rose the spines on back and side as if moved by a spring. Thus bravely encountered, the bandit beat an ignominious retreat down among the water-plants. The dull race of molluscs, Planorbinae, and water-snails were sucking in air on the surface of the water, and the great Water Beetle, with its hideous larva, went by wringing the neck now of one, now of another, without the stupid band seeming to notice it. But let us leave the waters of the plain and climb the steep cliff dividing us from the tableland where sheep are feeding and horses are being exercised for the approaching races, one and all bestowing largesse on the rejoicing dung beetles.

For here at work are the scavenger beetles to whom is entrusted the high office of clearing the

ground of impurities. It is impossible to admire sufficiently the variety of tools with which they are furnished, both to stir the dung with, to divide and shape it, and to hollow the deep retreats into which they shut themselves with their booty. These tools form a kind of technological museum, where there is a specimen of every kind of digging instrument. Some might be copied from those devised by human industry, others are of an original type, and might serve as models for new tools for man. *Copris hispanica* wears a strong horn on its head, forked and bent back, like the long spike of a pick-axe. To a similar horn *C. lunaris* adds two strong points, shaped liked a ploughshare, projecting from the thorax, and between them a sharp-edged protuberance, serving as a wide rake. *Bubas bubalus* and *B. bison*, both exclusively Mediterranean species, have foreheads armed with two stout, diverging horns, between which projects a horizontal share from the corslet. *Geotrupes typhæus* carries three points on the front of its thorax, parallel and standing straight out, the middle one shorter than the others. *Onthophagus taurus* owns as implements two long curving appendages like the horns of a bull, while the furcate *Onthophagus* has a two-pronged fork on its flat head. • Even those least well off have on one part or other hard tubercules—tools blunt indeed, but which the patient insect knows very well how to utilise. All are furnished with a shovel, *i.e.* a large, flat, sharp-edged head; all use a rake—in other words, they collect materials with their toothed front legs.

As compensation for their unpleasant work,

more than one gives out a strong scent of musk, and its ventral parts gleam like polished metal. *Geotrupes hypocrita* has the under part of its body bright with metallic lights of copper and gold, and *G. stercorarius* with amethystine violet. But the usual colour is black. It is in tropical regions that we find dung beetles in gorgeous array—absolutely living jewels. Under camel droppings in Upper Egypt is found a beetle rivalling the dazzling green of an emerald; Guiana, Brazil, Senegal, can show *Copridæ* of a metallic red, rich as the red of copper, bright as that of a ruby. If such a jewelled race be wanting to our country, still its dung beetles are not less remarkable for their habits.

What eagerness is displayed around a dropping! Never did adventurers from the four corners of the world show such eagerness in working a Californian claim! Before the sun grows too hot there they are by hundreds, large and small, pell-mell, of every kind and form and shape, hastening to secure a slice of the cake! Some work in the open air and rake the surface, some open galleries in the thickest part, seeking choice morsels, others toil in the under part and bury their treasure as soon as possible in the adjacent ground, and the smallest crumble some scrap fallen from the excavations of their strong fellow-workers. Some again—new-comers, and doubtless the hungriest—eat then and there, but the aim of the greater number is to lay up a store which will allow them to pass long days of plenty down in some sure retreat. A fresh dropping is not to be found just when wanted in a plain where no thyme grows; such a gift is

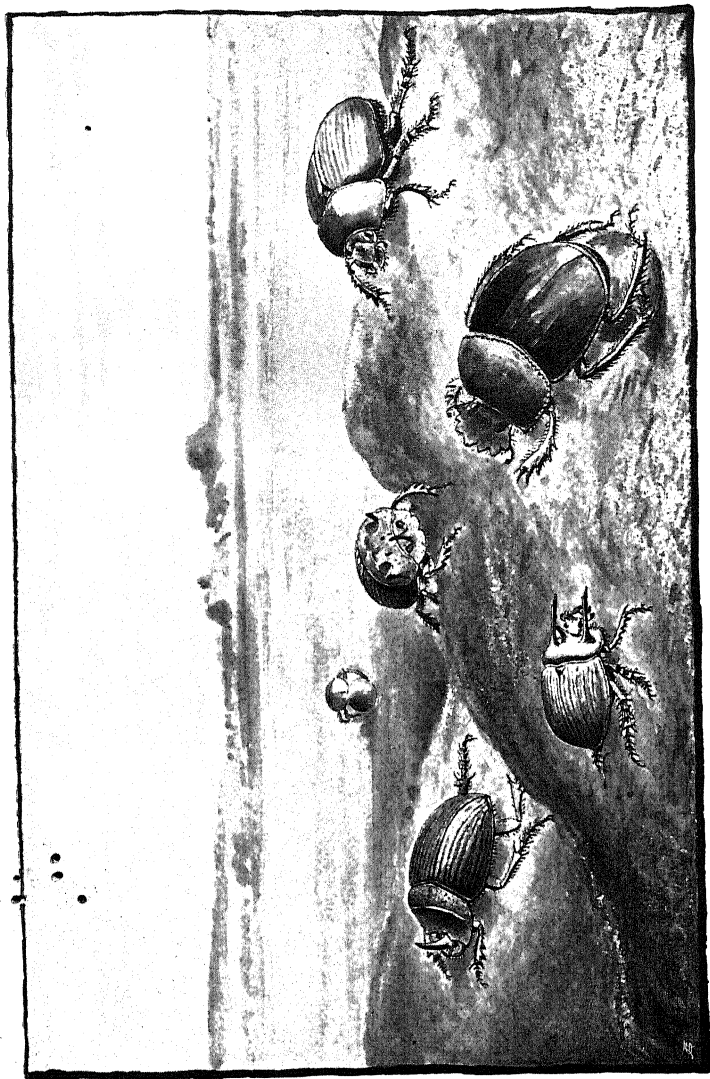
indeed a piece of good fortune, and only comes to the lucky. So when found, the wealth is prudently stored. The smell has carried the good news a couple of miles round, and all have rushed to gather up provender. Some laggards are still coming in on the wing or on foot.

What is the one now trotting towards the heap, fearing to arrive too late? His long legs work with a brusque, awkward action, as if moved by some machine inside him; his little red antennæ spread their fans—sure sign of anxious greediness. He is coming, has arrived, not without upsetting some of the guests. It is the Sacred Beetle, all in black, the largest and most celebrated of our dung beetles.

Here he is at table, beside his fellow-guests, who are giving last touches to their balls with the flat of their large front legs, or enriching them with a last layer before retiring to enjoy the fruit of their labours in peace. Let us follow this famous ball in each stage of construction.

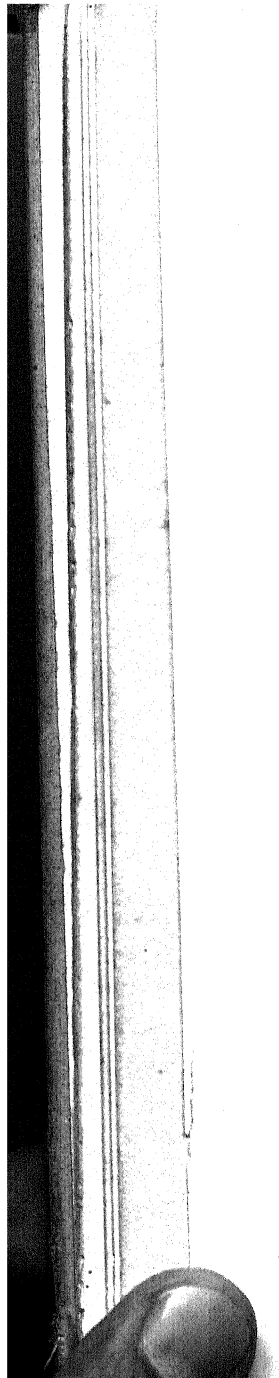
The edge of the beetle's head is large and flat, and armed with six angular teeth arranged in a semicircle. It is the tool for digging and dividing, the rake to lift or reject such vegetable fibres as are not nutritious, to seek out what is best and rake it together. A choice is thus made, for these keen • connoisseurs like one thing better than another—a somewhat careless choice, indeed, if the beetle alone be concerned, but one which is rigorously scrupulous if the maternal ball be in question, with its central hollow where the egg will hatch. Then every scrap of fibre is rejected, and only the quintessence of the stercorous matter is used to build the inner layer of

the cell. Then, as soon as it is hatched, the young larva finds in the walls of its dwelling a dainty food which strengthens digestion and enables it later to attack the coarse outer layers. For its own needs the beetle is less fastidious, contenting itself with a general selection. The toothed head hollows and seeks, rejects and gathers, somewhat at haphazard. The forelegs aid mightily. They are flattened, bent into the arc of a circle, are furnished with strong nerves and armed with five stout teeth. If an effort has to be made, an obstacle overthrown, a path forced through the thickest part of the heap, the dung beetle elbows its way; in other words, throws its toothed legs right and left, and clears a half circle with a vigorous sweep of its rake. Room being made, these same feet have a new task; they collect bundles of the material raked up by the head, and pass it under the insect to the four hindfeet. These are planned for the turner's trade. The legs, especially the last pair, are long and slender, slightly bent in an arc, and ending in a very sharp spur or talon. A glance shows that they form a spherical compass, capable of holding a globe in the bent legs to verify and correct its shape. In fact, their mission is to shape the ball. Bundle after bundle the material accumulates under the insect, held between the four legs which by a slight pressure lend it their own curve and something of shape. Then from time to time the rough hewn ball is set in motion between the legs of the double spherical compass, turned underneath the beetle, and rolled into a perfect sphere. Should the outer layer fail in plasticity and threaten to scale off, or if some



DUNG BEETLES GATHERING PROVENDER

[To face p. 6.]



part be too fibrous, and refuse to be shaped by rotation, the faulty part is retouched by the fore-foot; little taps of their broad surface give consistency to the new layer and imbed the recalcitrant fibre in the general mass. When the sun shines and work is urgent, one is amazed by the feverish activity with which the turner labours. Work goes on fast; first there was a pellet, now it is as large as a nut, by and by it will be of the size of an apple. I have seen some greedy beetles make up a ball as large as an apple. Assuredly there is food in the larder for some days to come!

Provender being gathered, the next thing is to retire from the *mêlée*, and carry it to a fitting place. Now we see some of the most characteristic habits of the Scarabæus. He sets out at once, embracing the ball with the long hind legs, whose talons, planted in the mass, serve as pivots—leans on the intermediary legs as pivots, and using as levers the flat of the toothed forefeet, which press the ground alternately, journeys backward with his load, the body bent, the head low, and the hinder part up-raised. The hind feet, which are the chief organs in the mechanism, move continually, going and coming and changing the place where the talons are stuck in, to alter the axis of rotation, to keep the load balanced and advance by an alternate push right and left. Thus the ball comes in contact with the ground in every part of it, which gives it a perfect shape and lends consistency to the outer layer by a uniform pressure. Courage! it moves, it rolls, and the journey's end will be reached, though not without trouble. Here is a first difficulty. The beetle

has to cross a slope, and the heavy ball would naturally follow the incline, but for reasons best known to itself, the insect prefers to cross this natural slope—an audacious plan, which one false step or a grain of sand to upset the balance will defeat. The false step is made, the ball rolls to the bottom of the valley, and the insect, upset by the impetus of its load, staggers, gets again on its legs, and hastens to harness itself afresh. The mechanism works capitally. But look out, scatterbrain! follow the hollow of the valley, it will spare labour and misadventure. The road is good and quite level, and your ball will roll along with no exertion. Not a bit of it. The insect has made up its mind to remount the slope already so fatal to it. Perhaps it suits it to return to the heights. Against that I have nothing to say, the *Scarabæus* knows better than I do whether it be advisable to dwell in lofty regions. At all events, take this path which will lead you up by a gentle incline. Not at all. If there be near at hand some very stiff slope impossible to climb, then that slope this wrong-headed insect prefers. Then begins the labour of *Sisyphus*. With endless precautions the monstrous load is painfully hoisted, step by step to a certain height, the beetle always going tail first. One asks one's self by what miracle of statics such a mass can be kept on the slope. Ah! a clumsy movement brings all this toil to naught. Down goes the ball, dragging the beetle with it. The escalade is repeated, soon followed by a fresh fall. The attempt is renewed, and better managed at the difficult points; a nasty grass-root, which occasioned the previous tumbles, is prudently

turned; we have almost got to the top. But gently! gently! the ascent is perilous, and a mere nothing may ruin all. A leg slips on a bit of smooth gravel, and ball and scavenger roll down together. The beetle begins all over again, with tireless obstinacy. Ten times, twenty times, will it attempt that further ascent, until persistency vanquishes all obstacles, or until, better advised, it takes the level road.

The scavenger does not always roll his ball single-handed, but frequently takes a partner, or rather, a partner takes him. The affair is usually managed thus: the ball being prepared, a beetle comes out of the throng, pushing it backwards. One of the newcomers, whose own work is hardly begun, leaves its task and runs to the ball, now in motion, to lend a hand to the lucky proprietor, who appears to accept the proffered aid in an amiable spirit. The two work as partners, each doing its best to convey the ball to a place of safety. Was a treaty made in the workshop, a tacit agreement to share the cake? While one kneaded and shaped, was the other tapping rich veins whence to extract choice material for their common use? I have never observed such collaboration, but have always seen every beetle exclusively occupied by his own affairs on the field of labour, so that the last comer has no acquired rights.

Is it, then, an association of the two sexes, a couple about to set up house? For a time I thought so. The two scavengers pushing a ball, one before and one behind, with equal zeal, used to remind me of certain couplets once on a time popular on barrel-organs—

Pour monter notre ménage, hélas comment ferons-nous ?
Toi devant, moi derrière, nous pousserons le tonneau.

But the evidence of the scalpel forces me to give up this family idyll. There is no outward sign of sex in the *Scarabæus*, but on dissecting a couple employed on one and the same ball they often turned out to be of the same sex. In fact, there is neither community of family nor community of labour. What, then, is the reason of the apparent partnership? Merely an attempt at filching. The eager fellow-worker, under pretence of giving a helping hand, cherishes the project of carrying off the ball at the earliest opportunity. To make one for itself at the heap demands labour and patience; to abstract a ready-made one, or at least to foist one's self in as a sharer of the feast, is much more convenient. If the owner's watchfulness should slacken, one will flee with the treasure; if too closely looked after, one can at least sit down at table on the pretext of services rendered. With such tactics all turns to profit, so that pillage is carried on as one of the most lucrative of trades. Some, as I have just said, play an underhand game, hastening to the aid of some comrade who has not the least need of them, and under the cloak of charitable assistance conceal a highly indelicate greed. Others, bolder or more confident in their strength, go straight to the goal and rob by main force. Every moment some such scene as this will take place. A beetle departs alone, rolling his ball, his own property, acquired by conscientious labour; another comes flying, whence I know not, drops heavily, folds his smoky wings under their elytra, and with the back of his toothed feet oversets the proprietor, which, being hindside before, cannot defend itself. While the latter

struggles to its feet the aggressor stations itself on the top of the ball, as a point of vantage whence to repel attack, folds its feet under its breast, ready for action, and awaits events. The bereaved owner moves round the ball, seeking a favourable point whence to attempt an assault; the thief revolves on the top of the citadel, constantly facing him. If the former raises itself for an escalade, the latter gives it a cuff which stretches it flat on its back. Secure on the top of the fortress, the besieged would bring to nought for all time the efforts of its adversary to recover its lost property if the besieger did not alter his tactics. Sapping threatens to bring down both citadel and garrison. The ball being undermined, staggers and rolls, carrying with it the robber, struggling his hardest to keep at the top, which he generally succeeds in doing, thanks to the hurried gymnastics that enable him to regain the altitude lost by the rotation of his standing place. If a false movement should bring him to the ground, the chances become equal, and the contest turns to a wrestling match. Robber and robbed grapple body to body, breast to breast. Their feet twist and untwist, their joints intertwine, their horny armour clashes and grinds with the harsh sound of filed metal. Then one will succeed in throwing its adversary on the back, and, freeing itself, hastily takes up a position on the top of the ball, and the siege is recommenced, now by the robber, now by the robbed, as the chances of the fight may have decided. The former, no doubt a hardy brigand and adventurer, often gets the best of it. After two or three defeats the ex-owner wearies of the contest

and returns philosophically to the heap and makes a new ball. As for the other, when all fear of a surprise is over, he harnesses himself to the conquered ball and pushes it whither it seems good to him. I have occasionally seen a third thief rob the robber. And upon my word I was not sorry.

Vainly do I ask myself what Prudhon introduced into Scarabæus-morality the audacious paradox that "Property spells theft," or what diplomatist taught the dung-beetle that "they may take who have the power, and they may keep who can." I have not the evidence required to lead me to the origin of these spoliations which have become a habit, or of this abuse of strength in order to seize a ball of dirt. All that I can affirm is that among beetles theft is universal. These dung rollers pillage one another with a cool effrontery really matchless. I leave it to future observers to elucidate this curious problem in the psychology of animals, and return to the couple rolling their balls in partnership.

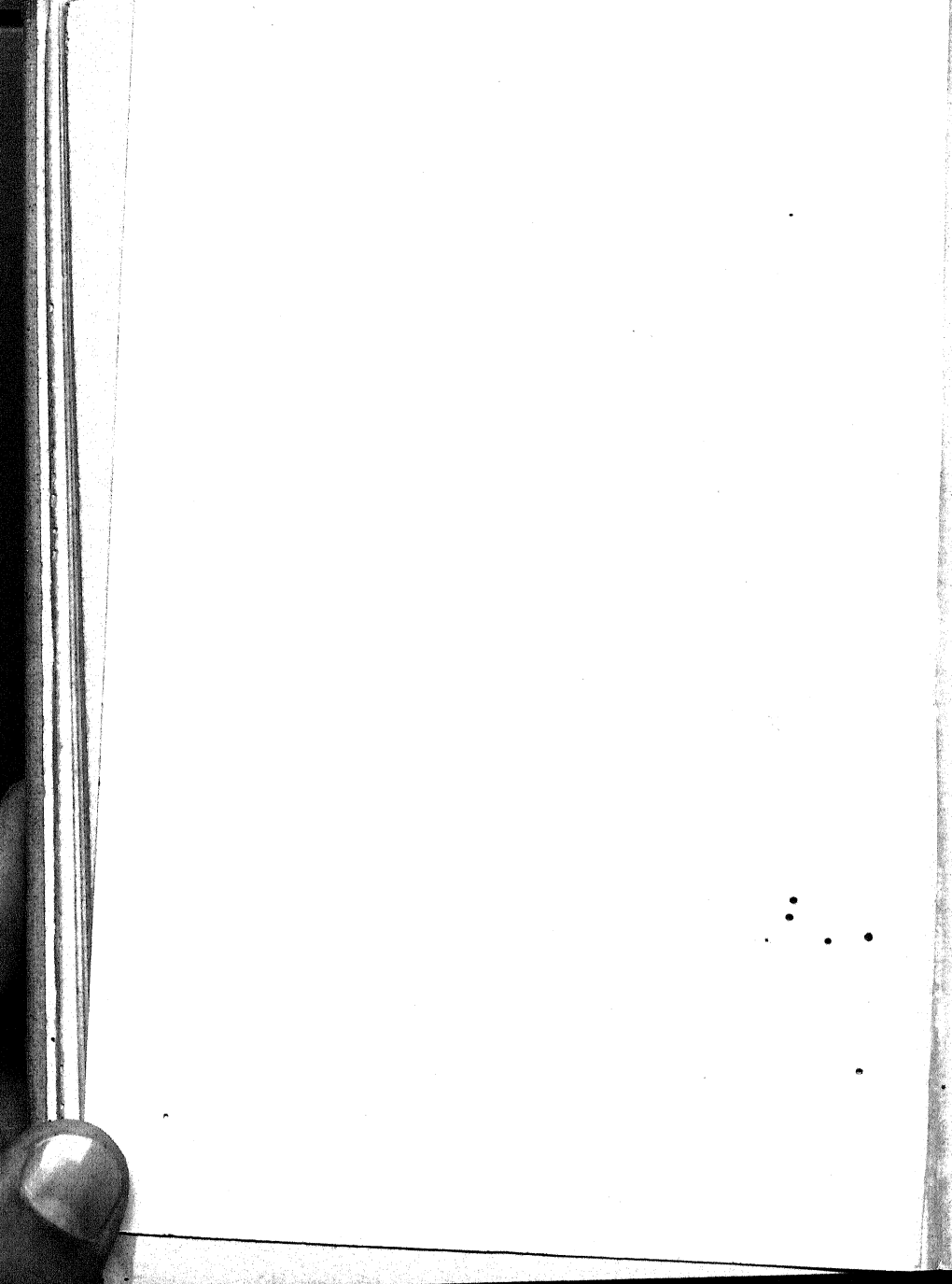
But first let us dissipate an error current in books. In the magnificent work of M. Emile Blanchard, *Metamorphoses, Habits, and Instincts of Animals*, I find the following passage: "Sometimes our insect is stopped by an insurmountable obstacle: the ball has fallen into a hole. At such a time the *Ateuchus*¹ displays a really astonishing grasp of the situation, and a yet more astonishing power of communication between individuals of the same species. Recognising the impossibility of getting the ball over the obstacle, the *Ateuchus* seemingly abandons it, and flies away. If you are sufficiently endowed

¹ The Scarabæus is also called *Ateuchus*.



GEOTRUPES STERCORARIUS FIGHTING FOR THE PELLET

[To face p. 12.]



with that great and noble virtue called Patience, remain near this forsaken ball. After a while the Ateuchus will return, and not alone; it will be followed by two, three, or four companions who, alighting at the appointed spot, will join in trying to lift up the load. The Ateuchus has been to seek reinforcements, and this explains why several beetles uniting to transport a single ball is such a common sight in dry fields." I also read in Illiger's *Entomological Magazine*: "A *Gymnopleurus pilularius*,¹ while constructing the ball of dung destined to contain its eggs, let it roll into a hole, whence the insect tried long and vainly to extract it. Finding this only waste of time, he hastened to a neighbouring heap of manure to seek three of his kind, which, uniting their efforts to his, succeeded in getting out the ball, and then went back to their own work."

I humbly beg pardon of my illustrious master, M. Blanchard, but assuredly things do not happen thus. First, the two accounts are so much alike that they must have had a common origin. After observations not followed up closely enough to merit blind confidence, Illiger put forward the story of his *Gymnopleurus*, and the same fact has been attributed to the *Scarabæus* because it really is a common thing to find two of these insects busy rolling a ball, or getting it out of some difficult position. But the partnership does not at all prove that one went to ask help from the other in some difficulty. I have had a large measure of the patience

¹ *G. pilularius* is a scavenger beetle nearly related to the *Scarabæus*. As its name suggests, it too rolls balls of dung. It is found very generally, even in the north, whereas *S. sacer* scarcely leaves the shores of the Mediterranean.

recommended by M. Blanchard ; I may claim to have spent long days in the intimacy of *Scarabæus sacer* ; I have tried every means to comprehend its manners and customs, and to study them from life, and never did I see anything which suggested that one had called its companions to its aid. As I shall presently relate, I have put the dung-beetle to proofs far more serious than that of a ball fallen into a hole, and into far graver difficulties than having to climb a slope—a thing which is mere sport for the obstinate Sisyphus, who seems to enjoy the rough gymnastics required by steep places, as if the ball grew thereby firmer, and therefore more valuable. I have invented situations where the insect had extreme need of help, and never could I detect any proof of good offices between comrades. I have seen pillaged and pillagers, and nothing else. If a number of beetles surrounded the same ball, it meant battle. My humble opinion is that several *Scarabæi* gathered round a pellet with intent to thief was what gave rise to these stories of comrades called in to give a helping hand. Incomplete observations have turned an audacious robber into a serviceable companion who put his own work aside to do a friendly turn. It is no slight thing to admit that an insect has a truly surprising grasp of the situation and a facility of communication between individuals more surprising still ; therefore I insist on this point, Are we to suppose that a *Scarabæus* in distress conceives the idea of begging for help?—flies off, explores the country round to find comrades at work on a dropping, and having found them, by some pantomime, especially by movements of the antennæ, addresses them more

or less thus: "Hullo, you there! My load is upset in a hole yonder; come and help me to get it out. I will do as much for you another time." And are we to suppose too that his colleagues understand him? And, more wonderful still, that they leave their work, their ball newly begun, their beloved ball, exposed to the greed of others, and certain to be filched during their absence, in order to help the supplicant! I am profoundly incredulous of so much self-sacrifice, and my incredulity is borne out by all which I have seen during many long years, not in collection boxes, but on the spots where the Scarabæi work. Outside of the cares of maternity—cares in which it almost always shows itself admirable, the Insect—unless, indeed, it lives in society like bees and ants and some others—thinks and cares for nothing but itself.

Let us drop this discussion, excused by the importance of the subject. I have already said that a Scarabæus, owner of a ball which it is pushing backwards, is often joined by another which hastens to its aid with interested views, ready to rob if it gets the chance. Let us call the pair associates, though that is hardly the name for them, since one forces itself on the other, who perhaps only accepts help for fear of worse. The meeting is, however, perfectly peaceable. The arrival of the assistant does not distract the proprietor for an instant from his labours; the newcomer seems animated by the best intentions, and instantly sets to work. The way they harness themselves is different for each. The owner of the ball occupies the chief position, the place of honour; he pushes behind the load, his

hind feet upraised, his head downward. The helper is in front, in a reverse position, head raised, toothed arms on the ball, long hind legs on the ground. Between the two moves the ball, pushed before it by the one, dragged towards it by the other. The efforts of the couple are not always harmonious, especially as the assistant turns his back to the road to be traversed, and the view of the owner is bounded by his load. Hence repeated accidents and ludicrous tumbles, taken cheerfully, each hastening to pick himself up and resume his former position. On level ground this style of draught does not answer to the expenditure of energy, for want of precision in combined movements; the *Scarabæus* behind would do as well or better alone, and the assistant, having proved his goodwill at the risk of disturbing the mechanism, decides to keep quiet of course without abandoning the precious globe, which he looks on as already his. A ball touched is a ball acquired. He will not be so imprudent as to let go; the other would instantly take advantage of it. So he folds his legs under him, flattens himself, incrusts himself, as it were, on the ball, and becomes part of it. Ball and beetle roll together, pushed along by the lawful owner. Whether it should go over the body of the other, whether he be above, below, or on one side of the rolling load, matters not—the intruder lies low. A singular helper this, who lets himself be run over for the sake of a share in the provender! But let them come to a steep incline, and he gets a chance of displaying his usefulness. On the steep slope he takes the lead, holding up the heavy load with his toothed feet while his

comrade steadies himself to hoist the load a little higher. Thus, by a combination of judicious efforts, I have seen them mount ascents, the one above holding up, the lower one pushing, where all the obstinate efforts of a single beetle must have failed. All, however, have not the same zeal in difficult moments; some, just when their assistance is most wanted on a slope, do not appear in the least aware that there is anything to overcome. While the unhappy Sisyphus is exhausting himself in efforts to surmount his difficulties, the other remains passive, incrusting on the ball, rolling down with it, and forthwith hoisted up again.

I have often tried the following experiment on two associates in order to judge of their inventive faculties in a serious predicament. Let us suppose them on level ground, the assistant firmly seated on the ball, the other pushing. Without disturbing the latter, I nail the ball to the ground with a long, strong pin; it comes to a sudden stop. The beetle, unaware of my treachery, doubtless believes in some rut, some dandelion root or pebble stopping the way. He redoubles his efforts, struggles his hardest, but nothing moves. What has happened? Let us go and see. Twice or thrice he walks round his pellet. Discovering nothing which can explain its immovableness, he goes behind and pushes again. The ball remains motionless. Let us look above. He climbs up to find nothing but his motionless colleague, for I have taken care to drive the head of the pin in deep enough to hide the head in the mass of the ball. He examines the summit and again descends; fresh thrusts are vigorously applied in

front and on either side with the same want of success. Certainly no scavenger beetle ever yet found himself confronted by such a problem of inertia. It is the very moment for claiming assistance, a thing all the more easy that the colleague is close at hand, squatted on the top of the dome. Will the *Scarabæus* give him a shake, or address him somewhat thus: What are you about, lazy bones? Come and look here; something has broken down. Nothing proves that he does so, for the beetle long persists in trying to move the immovable, examining now on this side, now on that, now above, now below, while his friend still remains quiescent. In the end, however, the latter becomes aware that something unusual is going on; it is brought home to him by the uneasy comings and goings of his companion and by the immobility of the ball, so in his turn he comes down to look into the matter. Double harness does not prove more effectual than single, and matters grow complicated. The little fans of their antennæ open and shut, open again, quiver and betray their lively anxiety. Then a stroke of genius ends their perplexities. Who knows what may be underneath? They explore below the ball, and a slight excavation reveals the pin. They recognise at once that the crux is there. Had I a voice in the matter I should have said, "An excavation must be made, and the stake which holds the ball must be got out." This very elementary proceeding, and one so easy to such expert excavators, was not adopted nor even attempted. The scavenger beetle was cleverer than the man. The two colleagues, one on this side, one

on that, insinuated themselves under the ball, which slipped up along the pin in proportion as the living wedges raised it, the softness of the material allowing of this clever manœuvre. Soon the ball was suspended at a height equal to that of the beetles' bodies. What remained to do was more difficult. From lying flat they gradually got on their legs and pushed upward with their backs. It was hard to accomplish, the feet losing strength the more they stretched upward, but they did it. Then came a moment when they could no longer use their backs to push, the highest point possible being reached. There was a last resource, but one much less favourable to the development of strength. Now in one of the postures in which it drags a ball, now in the other,—that is to say, either head downward or the reverse,—the insect pushes with hind or fore feet. Finally, unless the pin be too long, the ball drops to the ground. The perforation is repaired as best it can be, and the ball is at once dragged onward.

But if the pin should be too long, the ball remains suspended at a height which the insect cannot increase by rearing itself up. In this case, after vain evolutions around the inaccessible maypole, the beetles give up the struggle, unless you are kind-hearted enough to complete the work yourself, and restore their treasure, or unless you aid them by raising the floor with a little flat stone, a pedestal from whence the insect can continue its work. Its use does not seem to be immediately understood, for neither beetle shows any readiness to profit by it. However, by chance or otherwise, one gets on the stone. Oh, joy! as it passed it felt the ball touch its back.

Thereupon courage returns, and the struggle begins again. Standing on its platform the beetle stretches its joints, rounds its back, and hoists the pellet. When that no longer avails, it manœuvres with its feet, now upright, now head downward. There is a new pause and new signs of uneasiness when the limit of extension is reached. Without disturbing the creature let us put another little stone on the first. By the help of the new step, which gives a support for its levers, the insect pursues its task. Adding one step to another as required, I have seen the *Scarabæus*, perched on a shaky pile of three or four fingers' breadth, persisting in its labour until the ball was completely freed.

Had it some vague consciousness of the services rendered by the elevation of its point of leverage? I cannot believe it, although the beetle profited very cleverly by my platform of little stones, for if the very elementary idea of using a higher base to reach something too elevated was not beyond it, how was it that neither beetle bethought him of offering his back to the other, thus rendering the task possible? One assisting the other, they might have doubled the height attained. They are far indeed from any such combinations. Here, each pushes the ball with all its might, but pushes as if alone, without seeming to suspect the happy result which would be brought about by a combined effort. When the ball is fastened to the ground by a pin, they behave as they would when the ball is stopped by a loop of dandelion, or held by some slender bit of stalk which has got into the soft, rolling mass. My artifice brought about a stoppage not unlike

those which occur when the ball is rolling amid the many inequalities of the ground, and the insect acts as it would have acted in some circumstances where I had not interfered. It uses its back as a wedge and lever and pushes with its feet without at all varying its means of action, even when it might call a comrade to its help.

If it has to face the difficulties of a ball nailed to the ground with no assistant, its dynamic manœuvres are exactly the same, and it succeeds, so long as we give the indispensable help of a platform gradually built up. Should this help be refused, the Scarabæus, no longer stimulated by the touch of its beloved ball, loses hope, and sooner or later, no doubt with bitter regret, flies off, whither I know not. What I do know is, that it does not return with a squadron of companions whom it has implored to help it. What could it do with them, since it cannot utilise even the single comrade when one shares the ball? Perhaps, however, an experiment which suspends the pellet at a height inaccessible to the insect when its means of action are exhausted may be too much outside of ordinary conditions. Let us try a miniature ditch, deep enough and steep enough to prevent a beetle when placed at the bottom with its load from rolling it up. These are the exact conditions named by Blanchard and Illiger. What happens? When persistent yet fruitless efforts show the beetle that it can do nothing, it spreads its wings and flies off. Long, very long have I waited, on the faith of what these learned men say, expecting it to return with its friends, but I have always waited in vain. Often, too, many days later I have found the ball

just where I tried the experiment, either at the top of the pin or at the bottom of the hole, proving that nothing fresh had happened. A pellet abandoned from necessity is abandoned for good and all, without salvage by the help of other beetles. Dexterous use of wedge and lever to move the arrested ball is the highest intellectual effort I have ever seen in the *Scarabæus sacer*. As a counterpoise to what experiment refutes, namely, an appeal for help to brother beetles, I very willingly chronicle this feat of mechanics for the glorification of the *Scarabæus*. Straying over sandy plains thickset with thyme, ruts, and slopes, the ball is rolled for a while by the two partners, the material thus acquiring a firmness which they probably find palatable. By and by a favourable spot is selected. The proprietor, who has always kept the place of honour behind the ball and is the one who performs almost the whole work of draught, begins to hollow out the dining-room. Beside him is the ball, to which his associate clings, motionless. Head and toothed legs attack the sand, flinging quantities backward, and the excavation advances rapidly. Soon the insect disappears therein. Each time that he brings a load to upper air he never fails to glance at the ball to make sure that all is going on well. Now and again he brings it nearer to the edge of the cavity, feels it, and seems to gain new zeal from its contact. The other beetle, hypocrite that he is, continues to inspire confidence by his motionless attitude on the ball. Meanwhile, the underground hall grows larger and deeper, and the excavator appears more rarely, hindered by the extent of his labours. The moment is favourable,

the sleeper rouses up. The crafty partner decamps with the ball, dragging it behind him with the haste of a thief fearing to be caught in the act. This abuse of trust rouses my ire, but I let it pass in the interest of the story—time enough to interfere on behalf of morality if the upshot threaten to turn out ill.

Already the thief is some yards away. The robbed beetle comes up from his hole, looks, and finds nothing. No doubt he has himself had a hand in like proceedings. Scent and sight soon put him on the track and he hurriedly comes up with the robber, whereupon this sly dog promptly changes his position, gets on his hind legs and clasps the ball with his toothed arms as he does when acting helper. Ah, you rascal! I see through you! you would excuse yourself by declaring that the ball rolled down the slope, and that you are trying to stop it and take it home. I, however, who am an impartial witness, assert that the ball, being well balanced at the mouth of the hole, did not move of its own accord. Besides, the ground is level. I affirm that I saw you set it in motion and make off with unequivocal intentions. It was an attempt at larceny or I know nothing about it. My evidence not being taken into consideration, the owner listens mildly to his companion's excuses, and the two roll the ball back as if nothing had happened.

But if the thief can get far enough away, or can conceal his track by adroitly doubling back, the loss is irreparable. To have collected provisions under a fiery sun, to have conveyed them a weary way, to have hollowed out a comfortable banqueting hall in

the sand, and then, just when all is ready, and appetite whetted by toil lends charms to the prospect of the approaching feast, to find one's self suddenly robbed by a companion is certainly a reverse of fortune that would try most people's courage. But the dung beetle does not allow itself to be cast down by this malicious blow of fate; it rubs its cheeks, spreads its antennæ, sniffs the air, and flies to the nearest heap to begin again. This is a trait of character which I admire and envy.

Let us suppose the *Scarabæus* lucky enough to have met with a reliable partner, or, better still, that he has no self-invited associate. The hole is ready, made in friable earth, usually in sand, rather shallow, about the size of one's fist, communicating with the outer air by a short passage, just wide enough to let the ball pass. As soon as the provender is introduced, the *Scarabæus* shuts itself in, stopping up the mouth of the passage with fragments kept in reserve in a corner. Once the door is closed, nothing outside betrays the banqueting hall. And now hurrah! all is for the best, in the best of all possible worlds. The table is sumptuously laid, the ceiling tempers the heat of the sun, only allowing a gentle moist heat to penetrate; the calm, the darkness, the concert given by the field-cricket overhead, all favour digestion. Carried away by my interest, I have caught myself listening at the door, believing that I heard sung at table the famous

Ah! how sweet 'tis nought to do
When all around is endless stir.

from the opera of *Galathea*.

Who would dare disturb the beatitude of such a banquet? Alas! the desire for knowledge makes one capable of anything, and I have not shrunk from even this. I now give the result of thus violating the sanctity of home-life. The ball filled almost the whole space, the magnificent store of victuals rising from floor to ceiling, a narrow passage separated it from the walls. In this sat the banqueters, two at most, often but one, their faces to the table, their backs to the wall. When once they have taken their places nobody stirs, all their vital powers are absorbed by the digestive faculties. No little movement which might cause the loss of a mouthful, no daintiness which might waste the food—everything must be done decently and in order. To see them thus absorbed round a lump of dung, one would say that they were aware of their rôle as earth-cleansers, and consciously devoted themselves to that marvellous chemistry which out of impurity brings the flower that gladdens the eye, and the wing-cases of the Scarabæus which adorn the turf in springtime. To fit it for this all-important work, which turns into living matter the residue that horse and sheep cannot utilise, in spite of the perfection of their digestive organs, the dung beetle needs special tools. Accordingly anatomy shows the immense length of its intestine, which, folded repeatedly on itself, slowly deals with the material in its manifold circuits, and exhausts the very last atom capable of being used. Where the stomach of the herbivorous animal can extract nothing, this powerful alembic draws riches which under its influence become the ebony mail of the Scarabæus sacer, and a cuirass of gold and

rubies for other species. Sanitary principles require that this marvellous change be made as rapidly as possible ; therefore the Scarabæus is endowed with a matchless power of digestion. Once shut up with food, it never ceases to eat and digest until the whole store is devoured. Proof of this is easily come by. Open the cell where it has retired from the world at any hour and you find the insect eating, and behind it, still attached to the creature, is a continuous cord, rolled carelessly like a bundle of cables. Without going into particulars, we can guess what this cord represents. Mouthful by mouthful the great ball passes into the digestive organs, yielding up its nutritive principle, and reappearing spun into a rope. Now this unbroken cord, often without a joint and always hanging from the orifice, proves, with absolute certainty, how continuous is the action of digestion. By the time that the food is nearly eaten, the rope is astonishingly long. Where else could one find another stomach, that, to avoid any loss in the debit and credit ledger of life, can feast for a week or a fortnight on such miserable cheer ? When the whole mass has been digested, the hermit returns to daylight, seeks, finds, and shapes a new ball, and begins all over again. This royal life lasts one or two months, from June to July ; then, with the coming of the fierce heat, which the grasshoppers love, the Scarabæi take up summer quarters and bury themselves in the cool earth. With the first rains they reappear, less numerous and less active than in spring, but apparently taken up by the all-important task of continuing their race.

II

THE ENCLOSURE

If you seek among writers for information as to the habits of *Scarabæus sacer* in particular, and on the dung robbers in general, you find that science has not got beyond some of the beliefs current in the time of the Pharaohs. We are told that the ball which is dragged along contains an egg, and is a cradle where the larva will find board and lodging. The parents roll it over rough ground to make it round, and when shocks and shakes and tumbles all along the slopes have shaped it properly, they bury it and abandon it to mother earth.

So rough a start in life always seemed to me unlikely. How could a beetle's egg, so tender and fragile as it is, endure the rocking of its rolling cradle? There exists in the germ a spark of life which the slightest touch, the merest trifle, can extinguish, and is it likely that the parents should take it into their heads to lug it about over hill and dale for hours? Not they; maternal tenderness does not subject its progeny to the martyrdom of *Regulus*.

However, something more than logical reasoning

was required to sweep away received opinions. I therefore opened hundreds of balls rolled by the dung beetles and others out of holes dug under my eyes, and never, never did I find either a central niche or an egg in the pellets. They are invariably rough heaps of food, hastily shaped, with no particular structure inside them, merely provender with which the beetles shut themselves up to enjoy an orgy in peace for some days. They covet and steal them with an energy which they certainly would not show if it implied new family cares. It would be absurd for one *Scarabæus* to steal the eggs of another, each having enough to do in securing the future of its own. So on that point no more doubt can exist; the balls rolled by beetles never contain eggs.

My first attempt to resolve the thorny question as to the bringing up of the larva was by constructing an ample enclosure with an artificial soil of sand and soil constantly renewed. Some twenty *Scarabæus sacer* were introduced, together with *Copris*, *Gymnopleurus*, and *Onthophagus*, and never did entomological experiment cost me so many mortifications. The main difficulty was to renew the food. My landlord owned a stable and a horse. I gained the confidence of his servant, who first laughed at my plans, and then allowed himself to be gained over by a silver coin. Every breakfast for my beetles cost twopence halfpenny; never before did the budget of a scavenger beetle amount to such a sum. I can still see and shall always see Joseph, as, when after grooming his horse of a morning, he would raise his head a little above the wall between the two gardens and call "Heigh! heigh!" on

which I would hurry to receive a pot of manure. Discretion on both sides was necessary, as will be seen. One day his master appeared at the moment of transfer, and made up his mind that all his manure went over the wall, and that what he wanted for his cabbages went to grow my verbenas and narcissus. Vainly did I try to explain; my explanations seemed to him mere jests. Joseph got a sound scolding, was called this and that, and threatened with dismissal if it happened again. It did not.

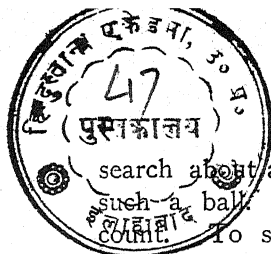
I still had the resource of going bashfully along the road with a twist of paper to gather up stealthily provisions for my pupils. I did so, and do not blush for it. Sometimes fate was kind. A donkey carrying the produce of the market-gardens of Château-Renard and Barbentane to Avignon would depose an offering as he passed my door. Such a gift, instantly collected, enriched me for several days. In short, by hook or by crook, by watching for a dropping, or turning diplomatist to get one, I succeeded in feeding my captives. If success is earned by an experiment conducted with a fervour that nothing can discourage, my experiment deserved to prosper. It did not. After some time my *Scarbæi*, consumed by home-sickness in a space which deprived them of their wider movements, let themselves die miserably without revealing their secret. *Gymnopleurus* and *Onthophagus* responded better to my expectations. In due time I shall use the information furnished by them.

Along with my attempts at education in an enclosed space, I carried on direct researches, the

results of which were far from what I desired. I felt that I must have assistants. Just then a joyous band of children were crossing the high land. It was a Thursday, and oblivious of school and hated lessons, an apple in one hand and a piece of bread in the other, they were coming from the neighbouring village of Les Angles and wending their way to search on the bare hill where the bullets drop when the garrison is shooting at a mark. A few bits of lead, worth about a halfpenny, were the object of this early morning expedition.

The tiny rosy flowers of wild geranium enamelled the turf which for a brief moment beautified this Arabia Petrea; the water wagtail, half black, half white, uttered its scornful cry as it fluttered from one point of rock to another; on the threshold of burrows, dug at the foot of tufts of thyme, the field-cricket filled the air with their monotonous symphony. And the children were happy in this festival of spring—happier still at their prospective riches—that halfpenny which they would get in return for the bullets they would find, that halfpenny which would enable them next Sunday to buy at the stall set up before the church two peppermint bull's-eyes—two great bull's-eyes at a farthing apiece!

I accosted the tallest, whose wide-awake air gave me hopes of him; the little ones formed a circle, each munching his apple; I explained the matter and showed them *Scarabæus sacer* rolling his ball, and told them that in a like ball, buried somewhere, I knew not where, a hollow is sometimes found, and in this hollow a grub. The thing to be done was to



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search about and watch the beetles in order to find such a ball. Those with no maggot would not count. To stimulate the children by a fabulous sum which would henceforward secure to me the time hitherto devoted to some farthing's worth of lead, I promised a franc, a lovely new coin worth twenty halfpennies, for each inhabited ball. At the mention of this sum eyes opened wide with delightful *naïveté*. I had quite upset their ideas on the subject of money by naming this exorbitant price as the value of a piece of dirt. Then, to show I was in good earnest, I distributed some halfpence to clinch the bargain. The following week at the same day and hour I was to appear at the same place and faithfully perform the conditions of our compact towards all who should have made the precious discovery. Having thoroughly posted up all the party, I dismissed the children. "He really means it!" they said as they went away; "he really means it! If we could only get one apiece!" and with hearts swelling with sweet hope, they clinked their pence in the hollow of the hand. The flattened bullets were forgotten. I saw the children scatter over the plain and hunt about.

On the appointed day the week after I returned to the tableland confident of success. My young helpers would no doubt have mentioned this lucrative trade in beetle-balls to their comrades and shown their handsels to convince the incredulous. Accordingly I found a larger party assembled than the first time. On seeing me they ran up, but there was no eagerness, no shout of joy. I saw that things had gone ill. Many times on coming out of

school had they sought for what I had described, but in vain. Some balls, found underground with the *Scarabæus*, were brought, but they were mere heaps of food, and there was no grub. Fresh explanations were given and a new appointment was made for the following Thursday. Again the same want of success. The seekers, discouraged, were now few. I made a last appeal, but nothing came of it. Finally, I paid the most zealous, those who had been faithful to the last, and we dissolved partnership. I could count on no one but myself for researches, which seemed simple enough, but really were exceedingly difficult. Even up to the present time, after many years, excavations made in favourable spots and hopeful opportunities have not yet given any clear, consistent result. I am reduced to combining incomplete observations and to filling up gaps by analogy.¹ The little which I have seen, together with observations on other dung beetles—*Gymnopterus*, *Copris*, and *Onthophagus*—in my enclosure is summed up in the following statement.

The ball destined for the egg is not fashioned in public, in the hurry-scurry of the general workshop. It is a work of art and much patience, demanding minute care impossible amid a crowd. One must retire to meditate one's plans and set to work, so the mother makes a hollow from four to eight inches deep in the sand. It is a rather spacious hall, communicating with the outside by a much narrower gallery. The insect carries down choice materials, no doubt first rolled into pellets. She must make

¹ Fabre subsequently completed the whole life-history and published it in the fifth series of his *Souvenirs* (1897).

many journeys, for the contents of the hole are out of all proportion with the door, and could not be carried in at once. I recollect a Spanish Copris which, at the moment I came upon it, was finishing a ball as large as an orange at the bottom of a burrow only communicating with the outside world by means of a gallery where I could but just insert my finger. It is true that the Copris do not roll balls or make long journeys to fetch food. They dig a hole immediately under the dung, and crawl backward with successive loads to the bottom of their cavity. The facility for provisioning and the security offered by working under the manure favour a taste for luxury not to be expected in the same degree among beetles belonging to the rude trade of ball-rollers; but should it return two or three times, *Scarabæus sacer* can amass wealth of which *Copris hispanica* might well be jealous.

So far the insect has only raw material, put together anyhow. The first thing to do is to select very carefully, taking what is most delicate for the inner layers, upon which the larva will feed, and the coarser for the outer ones which merely serve as a protecting shell. Then around a central hollow which receives the egg the materials must be arranged layer after layer, according to their decreasing fineness and nutritive value; the strata must be made consistent and adhere one to another; and finally, the bits of fibre in the outside crust, which has to protect the whole thing, must be felted together. How can the *Scarabæus*, clumsy and stiff as it seems, accomplish such a work in complete darkness, at the bottom of a hole so full of provisions that there is

barely room to move? When I think how delicate is the work done and how rude the tools of the workman,—of the angular feet fitted to hollow the ground, and, if need be, even tufa,—I am reminded of an elephant trying to make lace. Explain who can this miracle of maternal industry; I give it up, especially as it has not been my good fortune to see the artist at work. Let us restrict ourselves to describing this masterpiece.

The ball which contains the egg is generally as large as a middle-sized apple. In the midst is an oval cavity about a centimetre in diameter. At the bottom is the egg, fixed vertically; it is cylindrical, rounded at each end, yellowish-white, about as large as a grain of wheat, but shorter. The wall of the hollow is washed over with a greenish-brown, semi-fluid matter, manure cream, destined as the first food of the larva. Does the mother collect the quintessence of the dung to make this delicate food? The look of it tells me that it is a pap prepared in the maternal stomach. The pigeon softens grain in its crop, and turns it into a kind of milk food which it disgorges for its nestlings. It would seem that the beetle shows the same tender care. It half digests the choice food, and disgorges it in the shape of a delicate film to line the walls of the cavity where the egg is laid. Thus, when first hatched, the larva finds food easy of digestion, which rapidly strengthens its stomach and allows it to attack the under layers which lack the same refinement of preparation. Under the semi-fluid paste is a choice pulp, compact and homogeneous, whence every particle of fibre is banished. Beyond are the coarser strata

where vegetable fibres abound, and finally the outside of the ball is composed of the coarsest materials felted together into a resistant shell. Manifestly there is a progressive change of diet. On issuing from the egg the feeble grub licks the fine paste on the walls of its dwelling. There is but little of it, still it is strengthening and of high nutritious value. To the bottle of early infancy succeeds the pap of the weanling, intermediate between the dainty fare of the start and the coarse nourishment at the end. This layer is thick enough and abundant enough to make the maggot into a robust grub. Then, strong food for the strong, barley bread with its husks, raw dung full of sharp bits of hay. The larva is superabundantly provisioned with it, and, having attained its growth, comes to the imprisoning outer layer. The capacity of the dwelling has increased with that of its inhabitant. The small original cavity with its excessively thick walls is now a large cell with sides only a few lines thick. The inner layers have turned into larva, nymph, or *Scarabæus*, as the case may be. In short, the ball is now a shell, hiding within its spacious interior the mysteries of metamorphosis.

My observations go no further; my certificates of the birth and condition of the *Scarabæus* do not go beyond the egg; I have not actually seen the larva which, however, is known and described by various authors. Neither have I seen the perfect insect while yet enclosed in the cell, previous to exercising its functions as ball-roller and excavator, and that is exactly what I should most have desired to see. I should have liked to find the

creature in its birthplace, recently transformed, new to all labour, so that I might have examined the worker's hand before it set to its tasks, and for the following reason.

Insects have each foot terminated by a kind of finger or tarsus, composed of a series of delicate portions which may be compared to the joints of our fingers. They end in a crooked nail. One claw to each foot is the rule, and this claw, at least in the case of the superior Coleoptera, especially the scavenger beetles, contains five joints. Now by a strange exception, the *Scarabæus* has no tarsi on its forefeet, while possessing well-shaped ones with five joints on the two other pairs. They are imperfect, maimed, wanting in their front limbs in that which represents, roughly indeed, our hand in an insect. A like anomaly is found in the *Onitis* and *Bubas*, also of the scavenger family. Entomology has long noted this curious fact without being able to give a satisfactory explanation. Is it a birth imperfection? Does the beetle come into the world without fingers on its front limbs, or does it lose them as soon as it enters on its toilsome labours?

One might easily suppose such mutilation a consequence of the insect's hard work. To grope, to excavate, to rake, to divide now among the gravel in the soil, now in the fibrous mass of manure, is not a work in which organs so delicate as the tarsi can be used without danger. Yet graver is it that when the insect is rolling its ball backward, head downward, it is with the end of the forefeet that it grips the ground. What becomes of the weak feet, no thicker than a thread, in this perpetual contact

with all the inequalities of the soil? They are useless—merely in the way, and sooner or later they are bound to disappear, crushed, torn off, worn out. Our workmen, alas! are too often maimed by handling heavy tools, and lifting great weights, and the same may be the case with the *Scarabæus* which rolls a ball that to it is a huge load. In that case the maimed arms would be a noble certificate of a life of toil.

But serious doubts at once suggest themselves. If these mutilations be accidental, and the result of laborious work, they should be the exception, not the rule. Because a workman or several workmen have had a hand crushed in machinery, it does not follow that all others should be maimed. If the *Scarabæus* often, or even very often, loses the fore-claws in its trade of ball-roller, there must be some which, cleverer or more fortunate, have preserved their tarsi. Let us then consult facts. I have observed a very large number of the species of *Scarabæus* which inhabit France, the *S. sacer*, common in Provence; *S. semipunctatus*, which is seldom found far from the sea, and frequents the sandy shores of Cette, Palavas, and of the Gulf of Juan; also *S. longicollis*, which is much more widely spread than the two others, and found at least as far up the Rhône Valley as Lyons. Finally, I have observed an African kind, *S. cicatricosus*, found in the environs of Constantine, and the want of tarsi on the fore-feet has proved invariable in all four species, at all events as far as my observations go. Therefore the *Scarabæus* is maimed from birth, and it must be no accident but a natural peculiarity.

Moreover, we have further proof in another reason. Were the absence of fore-claws accidental, and the consequence of rough labour, there are other insects, especially among the scavenger beetles, which undertake excavations yet more difficult than those of the Scarabæus, and which ought therefore to be still more liable to lose their front claws, as these are useless and in the way when the foot has to serve as a strong tool for excavation. For instance, the Geotrupes, who deserve their name of Earth-piecer so well, make hollows in the hard and beaten soil of paths among pebbles cemented by clay—vertical pits so deep that to reach the lowest cell one has to use powerful digging tools, and even then one does not always succeed. Now these miners *par excellence*, who easily open long galleries in surroundings whose surface the Scarabæus sacer could hardly disturb, have their front tarsi intact, as if to perforate tufa were a work calling for delicacy rather than strength. Everything then points to the belief that, if observed in its natal cell, the baby Scarabæus would be found mutilated like the veteran who has travelled the world and grown worn with labour.

On this absence of fingers might be based an argument in favour of the theories now in fashion—the struggle for life and the evolution of the species. One might say that the Scarabæus had originally tarsi on all its feet in conformity with the general laws of insect organisation. One way or another, some have lost these embarrassing appendages on their forefeet, they being hurtful rather than useful. Finding themselves the better for this mutilation,

which proved favourable to their work, little by little they gained a superiority over the less favoured ones, founded a race by transmitting their fingerless stumps to their descendants, and finally, the primitively fingered insect became the fingerless *Scarabæus* of our time. I am willing to agree to this reasoning if it could first be demonstrated why, with like labours,—labours even far harder,—the *Geotrupes* has preserved his tarsi. Meantime let us continue to believe that the first *Scarabæus* who rolled a ball, perhaps on the shores of some lake where bathed the *Palæotherium*, was as much without tarsi as him of our own day.

III

CERCERIS BUPRESTICIDA

EVERY one has met with books which, according to his turn of mind, have been epoch-making, opening to him horizons whose very existence he had never guessed. They throw wide open the gates of a new world where henceforward he will use his mental powers; they are the spark which, falling on a hearth, kindles into flame materials otherwise never utilised. And very often it is mere chance which puts into our hands some book which makes a new starting-point in the evolution of our ideas. The most casual circumstance, a few lines which happen to come under our eye, decide our future and impel us into the path which thenceforward we shall follow. One winter evening, beside a stove where the ashes were yet warm, while my family slept, I was forgetting, while I read, all the cares of the morrow—the black cares of the professor of physics, who, after having piled one university diploma on another and rendered for a quarter of a century services whose merit was not denied, earns for himself and family 1600 francs—less than a groom in a well-to-do household. Such was the shameful

parsimony of that day in educational matters ; thus did Red tape will it. I was a free-lance, son of my solitary studies. Thus, amid my books I was putting aside acute professorial worries when I chanced to light on an entomological pamphlet which had come into my hands I forget how. It was by the patriarch of entomology of that day, the venerable savant Léon Dufour, on the habits of a Hymenopteron whose prey was the Buprestis. Certainly long ere this I had felt a great interest in insects ; from childhood I had delighted in beetles, bees, and butterflies ; as far back as I can recollect I see myself enraptured by the splendours of a beetle's elytra, or the wings of the great Swallowtail butterfly. The materials lay ready on the hearth, but the spark to kindle them had been lacking. The accidental perusal of Léon Dufour's pamphlet was that spark. I had a mental revelation. So then to arrange lovely beetles in a cork box, to name and classify was not the whole of science ; there was something far superior, namely, the close study of the structure, and still more of the faculties of insects. Thrilled by emotion I read of a grand instance of this. A little later, aided by those fortunate circumstances which always befriend the ardent seeker, I published my first entomological work, the complement of Léon Dufour's. It gained the honours of the Institute of France, a prize for experimental physiology being adjudged to it, and—far sweeter reward !—shortly after I received a most flattering and encouraging letter from the very man who had inspired me. From far away in the Landes the venerated master sent me the cordial expression

of his enthusiasm, and urged me to continue my studies. At that recollection my old eyes still grow wet with a holy emotion. Oh, bright days of illusion, of faith in the future, what has become of you!

I hope that the reader will not be sorry to meet with an extract from the pamphlet which was the starting-point of my own researches, the more so that it is necessary for the understanding of what follows. So I will let my Master speak, only abridging slightly :—

In all insect history I know of no fact more curious and extraordinary than that which I am about to relate. It concerns a species of *Cerceris* which feeds its progeny on the most splendid kinds of *Buprestis*. Let me share with you, my friend, the vivid impressions gained by studying the habits of this Hymenopteron. In July 1839 a friend, who lives in the country, sent me two *Buprestis bifasciata*, an insect new to my collection, telling me that a kind of wasp which was carrying one of these pretty beetles had dropped it on his coat, and that a few minutes later a similar wasp had let fall another on the ground. In July 1840, having been called in as physician by my friend, I reminded him of his capture of the preceding year, and asked about the circumstances. Season and place corresponding with it, I hoped to do as much myself, but that particular day was dark and chilly, unfavourable therefore to the flight of Hymenoptera. Nevertheless, we made a tour of inspection in the garden walks, and seeing no insects I bethought myself of seeking in the ground for the homes of burrowing Hymenoptera. A tiny heap of sand recently thrown up, like a miniature mole-hill, attracted my attention. Scratching it away, I saw that it masked the orifice of a gallery descending far down. We carefully dug up the ground with a spade, and soon caught sight of the shining elytra of the coveted *Buprestis*. Soon I not only found wing-cases but a whole *Buprestis*, nay,

three and four displayed their gold and emerald. I could not believe my eyes. But that was only the prelude to my feast. In the chaos caused by my own exhumations a Hymenopteron appeared and was taken by me; it was the captor of the Buprestis, trying to escape from amid her victims. I recognised an old acquaintance, a *Cerceris* which I have found some two hundred times in Spain and around Saint Sever.

But my ambition was far from satisfied. It was not enough to know ravisher and prey: I wanted the larva for which all this rich store was laid up. After exhausting the first vein of Buprestis I hastened to make new excavations. Digging down more carefully I finally discovered two larvæ, which completed the good fortune of this campaign. In less than an hour I turned over three haunts of the *Cerceris*, and my booty was some fifteen whole Buprestids with fragments of a yet greater number. I calculated, and I believe it fell far short of the truth, that there were twenty-five nests in this garden, a fact representing an immense number of buried Buprestids. What must it be, I said to myself, in localities where in a few hours I have caught as many as sixty *Cerceris* on blossoming garlic, with nests most probably near, and no doubt provisioned quite as abundantly! Imagination, backed by probability, showed me underground, within a small space, *B. bifasciata* by thousands, although I who have observed the entomology of our parts for over thirty years have never noticed a single one. Once only, perhaps twenty years ago, did I see, sticking in a hole of an ancient oak, the abdomen and elytra of this insect. This fact was a ray of light, for it told me that the larva of *B. bifasciata* must live in the wood of the oak, and entirely explained the abundance of this beetle in a district where the forests consist chiefly of that tree. As *Cerceris bupresticida* is rare on the clayey hills of the latter stretch of country compared to the sandy plains where grows *Pinus maritima*, it became an interesting question whether this Hymenopteron when it inhabits the pine region provisions its nest as it does in

the oak district. I had good reason to believe that it did not, and you will soon see with some surprise how exquisite is the entomological tact of our *Cerceris* in her choice of the numerous kind of Buprestids.

Let us hasten to the pine region to taste new pleasures. The spot to be explored is a garden belonging to a property in the midst of forests of the maritime pines. The haunts of the *Cerceris* were soon recognised; they were exclusively found in the main paths, where the beaten and compact soil offered the burrowing Hymenoptera sufficient solidity for the construction of their subterranean dwellings. I visited some twenty, and I did it, I may say, by the sweat of my brow. It is a very laborious kind of exploration, for the nests and provisions are only found at the depth of one foot, so that it is necessary to invest the place by a line of square trenches seven or eight inches from the mouth of the hole, first inserting a stalk of grass in the gallery by way of clue. One must sap with a garden spade, so that the central clod, thoroughly detached all round, may be raised in one piece, then reversed on the ground and broken up carefully. Such is the manoeuvre which I found successful. You would have shared our enthusiasm at the sight of the beautiful species of Buprestis which this new style of research revealed to our eager gaze. You ought to have heard our exclamations as each time the clod was reversed, new treasures were revealed rendered yet more brilliant by the hot sun, or when we discovered the larvæ of every age attached to their prey, or the cocoons of these larvæ incrustated with copper, bronze, and emerald. I who had been for three or four times ten years, alas! a practical entomologist had never beheld such an enchanting sight or had had such good fortune. We only wanted you to double our enjoyment. With ever increasing admiration we dwelt now on the brilliant Coleoptera and now on the marvellous sagacity of the *Cerceris* which had buried and laid them up for food. Can you believe it? Out of more than 400 beetles dug up, there was not one which did not belong to the old

genus *Buprestis*! Our Hymenopteron had not committed the smallest error. How much there is to learn from this intelligent industry in so small an insect! What value Latreille would have attached to the vote of this *Cerceris* in favour of the natural system!¹

Let us pass on to the various contrivances of the *Cerceris* in making and provisioning her nest. I have already said that she chooses ground whose surface is beaten, compact, and solid. I should add that this ground must be dry and in full sunshine. This choice shows an intelligence, or, if you like, an instinct, which one is tempted to believe is the result of experience. Crumbly earth or mere sand would of course be easier to work, but then how construct an orifice which will remain wide open for ingress and exit, and a gallery whose walls will not constantly fall in, yield, and become blocked by the least rain? The choice is therefore both reasonable and perfectly well calculated.

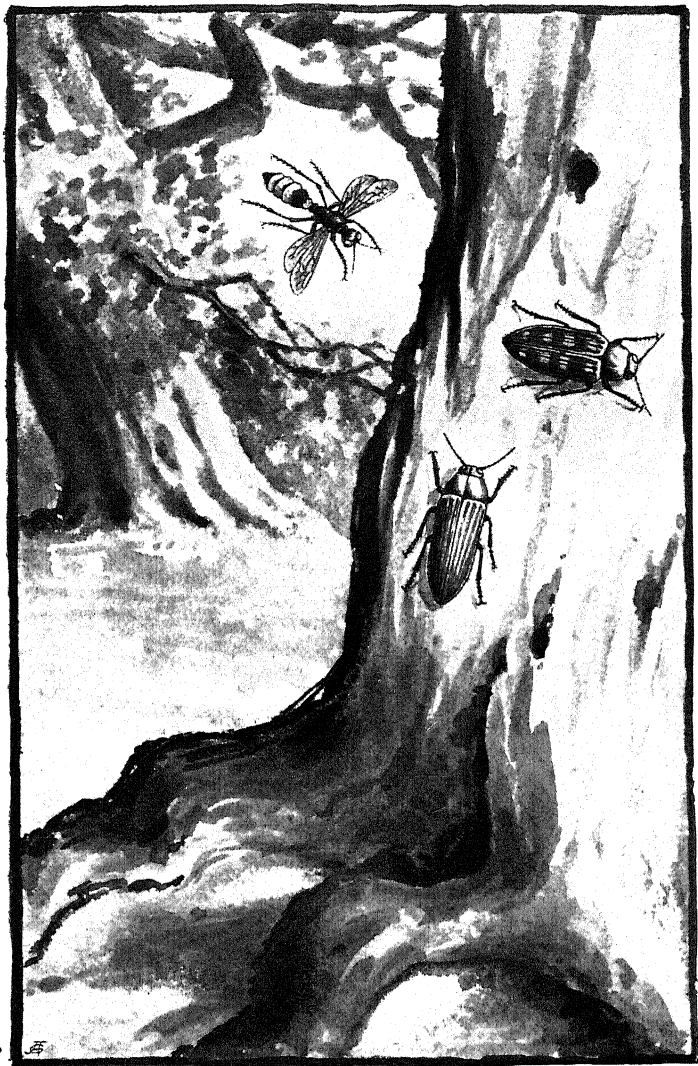
Our burrowing Hymenopteron hollows her gallery with her mandibles and front tarsi, which accordingly are furnished with stiff points to act as rakes. The orifice must not only have the diameter of the miner's body, but be able to admit a prey of larger bulk. This shows admirable forethought. As the *Cerceris* digs deeper she brings out the rubbish, and this makes the heap which I compared to a tiny molehill. The gallery is not vertical, as this would have exposed it to be filled up by wind or other causes. Not far from the starting-point it makes an angle; its length is from seven to eight inches. At the far end the industrious mother establishes the cradle of her progeny. Five cells, separate and independent of one another, are hollowed in the shape and nearly of the size of an olive; within they are solid and polished. Each can contain three *Buprestids*, the ordinary allowance for a larva. The *Cerceris* lays an egg amid the three victims, and then stops up the gallery with

¹ The beetles dug up belonged to the following species:—*Buprestis octoguttata*, *B. bifasciata*, *B. pruni*, *B. tarda*, *B. biguttata*, *B. micans*, *B. flavomaculata*, *B. chrysostigma*, *B. novem-maculata*.

earth, so that when once the provisions for the brood are laid in, the cells have no communication with the outside.

Cerceris bupresticida must be an indefatigable, daring, and skilful huntress. The cleanness, the freshness of the beetles which she buries in her den testify that they are seized just as they emerge from the wooden galleries where their final metamorphosis takes place. But what inconceivable instinct urges a creature that lives solely on the nectar of flowers to seek amid a thousand difficulties animal food for carnivorous offspring, which it will never see, and to post itself on trees quite unlike one another, which hide deep in their trunks the insects which are to fall her victims? What entomological tact, yet more inconceivable, makes her lay down a strict law to select them in a single generic group, and to catch species differing very considerably in size, shape, and colour? You observe how unlike are *Buprestis biguttata*, with its slender long body and dark colour; *B. octoguttata*, oval-oblong, with great stains of a beautiful yellow on a blue or green ground; and *B. micans*, three or four times the size of *B. biguttata*, with a splendid metallic greeny gold.

There is another very singular fact in the manoeuvres of our assassin of Buprestids. The buried ones, like those which I have seized in the grasp of their murderers, give no sign of life, and are unquestionably quite dead, yet, as I observed with surprise, no matter when they are dug up, not only do they keep all their freshness of colour, but every bit of them—feet, antennæ, palpi, and the membranes which unite the various parts of their bodies—is perfectly supple and flexible. At first one supposes the explanation, as far as concerns the buried ones, to be in the coolness of the ground, and absence of air and light, and for those taken from their murderers, in the very recent date of death. But observe that after my explorations, having isolated in cones of paper the numerous Buprestids dug up, I have often left them over thirty-six hours before pinning them out. And yet, notwithstanding the dryness and great heat of July, I have always found the same



CERCERIS BUPRESTICIDA AND ITS PREY, BUPRESTICIS MICANS AND
BUPRESTIS FLAVOMACULATA

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flexibility in the joints. More than this, after that lapse of time, I have dissected several, and their viscera were as perfectly preserved as if I had used my scalpel on the live insect. Now, long experience has taught me that even in a beetle of this size, when twelve hours have passed in summer after its death, the interior organs are either dried up or corrupted so that it is impossible to be sure of form or structure. There is some peculiarity about Buprestids put to death by the *Cerceris* which prevents corruption or desiccation for a week, or perhaps two. But what is this peculiarity?

To explain this wonderful preservation which makes an insect dead for several weeks into a piece of game not even high, but, on the contrary, as fresh as when first caught, and that during the greatest heat of summer, the skilful historian of *Cerceris bupresticida* supposes that there must be an antiseptic liquid acting as do the preparations used in preserving anatomical specimens. This liquid can only be the poison injected by the Hymenopteron into the body of the victim. A minute globule of the venomous humour accompanying the dart or lancet, destined for this purpose, acts as a kind of pickle or antiseptic fluid to preserve the flesh on which the larva is to feed. But then how superior to our processes are those of the *Cerceris* with regard to preserved food! We salt or smoke or enclose in tins hermetically sealed provisions which remain eatable, to be sure, but which are far, very far from having the qualities of fresh meat. Sardines drowned in oil, Dutch smoked herrings, cod hardened into slabs by salt and sun,—can any of these sustain comparison with the same fish brought alive to the kitchen? For meat properly so-called it is still

worse. Beyond salting and drying we have nothing which even for a short period can keep meat eatable. At the present time, after innumerable fruitless attempts of the most varied kind, special ships are equipped at great cost, which, furnished with powerful freezing apparatus, convey to us the flesh of sheep and oxen slaughtered in the Pampas of South America, frozen and kept from corruption by intense cold. How far superior is the method of the *Cerceris*, so rapid, so cheap, so expeditious! What lessons we should have to learn from such transcendental chemistry when an imperceptible drop of liquid poison renders in an instant the prey incorruptible! What am I saying?—incorruptible?—that is far from being all; the game is put into a condition which prevents desiccation, leaves their suppleness to the limbs, and maintains all the organs in pristine freshness, both the internal and external. In short, the *Cerceris* puts the insect into a state differing only from life by a corpse-like immobility.

Such is the conclusion arrived at by Léon Dufour before this incomprehensible marvel of the dead *Buprestis* untouched by corruption. An antiseptic fluid, incomparably superior to anything that human science could produce, would explain the mystery. He, the Master, skilful of the skilful, thoroughly used to most delicate anatomy; he who with magnifying glass and scalpel has scrutinised the whole circuit of entomology, leaving no corner unexplored; he, in short, for whom the organisation of insects has no secrets,—can advance no better conjecture than an antiseptic liquid to give at least a kind of explanation of a fact which leaves him confounded. Let me

insist on this comparison between the instinct of the animal and the reason of the sage in order the better to demonstrate in due time the overwhelming superiority of the former.

I will add but a few words to the history of the *C. bupresticida*. This Hymenopteron, common in the Landes, as we have heard, seems to be rare in the department of Vacluse. It is only at long intervals that I have met with it, in autumn, and always isolated specimens, on the spiny heads of *Eryngium campestre*, in the environs of Avignon or round Orange and Carpentras. In the latter spot, so favourable to burrowing hymenoptera, from its sandy soil of Mollasse, I had the good fortune, not indeed of being present at the exhumation of such entomological riches as Léon Dufour describes, but of finding some old nests which I feel certain belonged to *Cerceris bupresticida*, from the shape of the cocoons, the kind of provender stored up, and the existence of the Hymenopteron in the neighbourhood. These nests, hollowed in a very friable sandstone, called *safre* in those parts, were filled with remains of beetles, easily recognised, and consisting of detached wing-cases, empty corslets, and whole feet. Now these remains of the larva's feast all belonged to one species, and this was a *Buprestis*, *Sphænoptera geminata*. Thus from the west to the east of France, from the department of the Landes to Vacluse, the *Cerceris* remains faithful to its favourite prey; longitude does not affect its predilections, a hunter of *Buprestids* among the maritime pines of the ocean sand-hills, it is equally so amid the evergreen oaks and olives of Provence.

The species is changed according to place, climate, and vegetation—causes influencing greatly the insect population, but the *Cerceris* keeps to its chosen genus, the *Buprestis*. For what strange reason? That is what I shall try to demonstrate.

IV

CERCERIS TUBERCULATA

WITH my mind full of the great deeds of the Buprestis hunter, I watched for an opportunity of observing in my turn the labours of the *Cerceris*, and I watched so closely that finally I got my chance. True, it was not the Hymenopteron celebrated by Dufour, with such sumptuous provisions that when dug up they made one think of the powder from a nugget broken by the miner's pick-axe in some gold field: it was a closely related species, a giant brigand which contents itself with more modest prey—in short, *Cerceris tuberculata* or *C. major*, the largest and strongest of the genus.

The last fortnight in September is the time when our Hymenopteron makes its burrows, and buries in the depths the prey destined for its brood. The position of the domicile, always sagaciously chosen, is governed by those mysterious laws varying with the species, but unchangeable for any one of them. The *Cerceris* of Léon Dufour requires a horizontal, beaten, compact soil, like that of a path, to avoid landslips and changes which would ruin its gallery with the first rain. Ours, on the

contrary, selects vertical ground. By this slight architectural modification she avoids most of the dangers which might threaten her tunnel; therefore she is not particular as to the nature of the soil, and hollows her gallery either in friable earth with a little clay, or in the crumbling soil of the Mollasse, which makes the labour of excavation much easier. The only indispensable condition seems to be that the soil should be dry, and exposed to the sun for the greater part of the day. It is therefore in the steep bank along a road, and in the sides of hollows made by rain in the sandy Mollasse, that our Hymenopteron makes its abode. Such conditions are frequent near Carpentras in what is known as the hollow way, and it is there that I have found *C. tuberculata* in the greatest abundance, and have collected most of the facts relating to its history.

It is not enough to choose this vertical situation; other precautions are taken to guard against the already advanced season. If some bit of hard sandstone project like a shelf, or if a hole the size of one's fist should have been hollowed naturally in the ground, it will be under this shelter or in this cavity that the gallery is made, a natural vestibule being thus added by the *Cerceris* to its own edifice. Although there is no kind of community among them, these insects like to associate in small parties, and I have always found their nests in groups of about ten, with orifices, though usually far apart, sometimes touching.

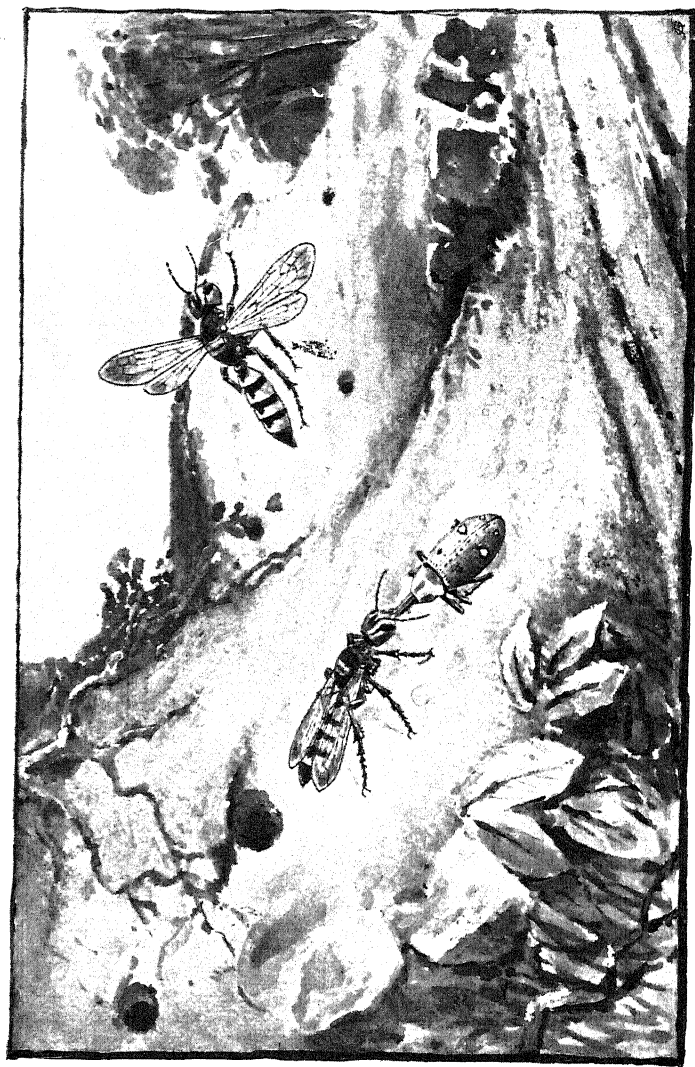
When the sun shines it is wonderful to see the ways of these hard-working miners. Some patiently extract bits of gravel from the bottom of a hole

with their mandibles, and push out the heavy mass; others scratch the walls of their tunnel with the sharp rakes of their tarsi, forming a heap of rubbish which they sweep out backward, and send sliding down the steep incline in long dusty streams. It was these periodical sand waves thrown out of galleries in process of construction which betrayed my first *Cerceris*, and led to the discovery of the nests. Others, either weary, or having completed their hard task, rested and polished their antennæ and wings under the natural caves which usually protect their dwelling, or else sat motionless at the mouth of their holes, only displaying their wide, square faces, barred with yellow and black. Others again were flying with a deep hum on the bushes near the cochineal oak, where the males, always on the watch near the burrows in process of construction, speedily join them. Couples form, often troubled by the arrival of a second male, which tries to supplant the happy possessor. The humming grows menacing, quarrels begin, and often both males roll in the dust until one acknowledges the superiority of his rival. Not far off the female waits with indifference the upshot of the struggle, accepting finally the male bestowed on her by the chances of the fight, and the pair fly out of sight to seek peace in some distant thicket. Here the part of the male ends. One half smaller than the females, they prowl about the burrows but never enter, and never take any part in the hard work of excavation, or that perhaps yet harder of provisioning the cells.

In a few days the galleries are ready, especially as after some repairs those of the preceding year

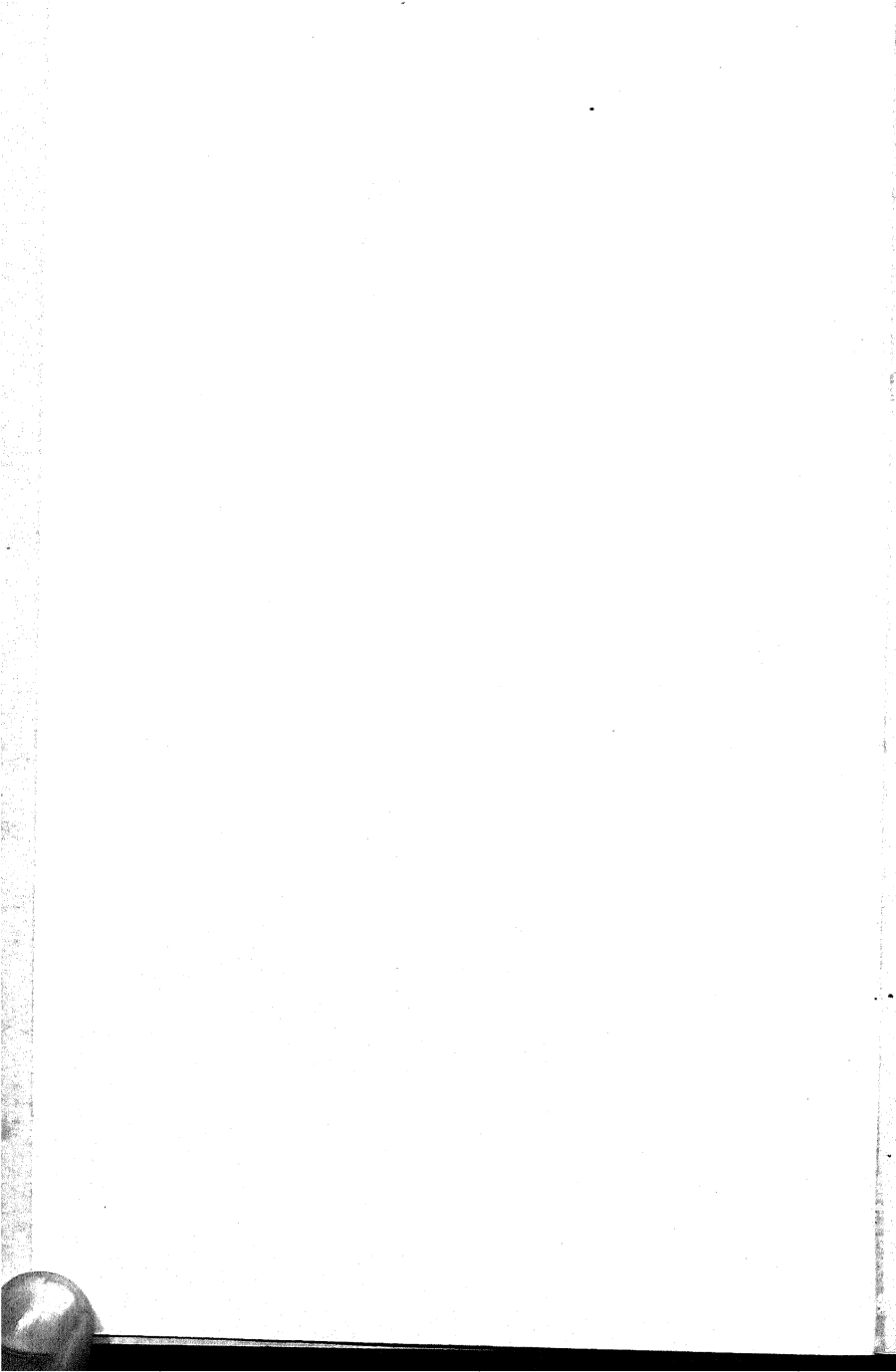
are used again. Other *Cerceris*, as far as I know, have no fixed home, transmitted from one generation to another. True Bohemians, they establish themselves wherever the chances of their vagabond life may lead them, so long as the soil suits them. But *C. tuberculata* is faithful to her penates. The projecting shelf of sandstone used by its predecessors is used again; it hollows out the same layer of sand hollowed by its forbears, and, adding its own labour to theirs, obtains deep-seated retreats sometimes only visited with difficulty. The diameter of the galleries would admit a thumb, and the insect can move about easily, even when laden with the prey which we shall see it capture. Their direction is horizontal, from four to eight inches, then makes a sudden turn downward more or less obliquely, now in one direction, now in another. Except the horizontal part, and the angle of the tunnel, the direction seems to depend on the difficulties of the ground, as is proved by the windings and changes in the farthest part of this kind of canal, which is half a yard in length. At the far end are the cells, not numerous, and provisioned with five or six dead beetles. But let us leave the details of how a *Cerceris* builds, and turn to more wonderful facts.

The victim chosen to feed the larvæ is a large weevil (*Cleonus ophthalmicus*). One sees the captor arrive, carrying the victim between its feet, body to body, head to head. It alights heavily some way from the hole to complete the journey without the aid of wings, and drags the prey laboriously with its jaws, on ground if not vertical, at least very steeply inclined, which often results in sending



CERCERIS TUBERCULATA DRAGGING WEEVIL TO ITS BURROW

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captor and captive headlong to the bottom, but the indefatigable mother finally darts into her burrow, covered with dust, but with the prey of which she has never let go. If she does not find walking with such a burden easy, it is otherwise with her flight, which is surprisingly powerful, if one considers that the strong little creature is carrying a prey nearly as large as and heavier than herself. I have had the curiosity to weigh the *Cerceris* and her prey separately, and the first weighed 150 milligrammes, and the second about 250, almost double.

These weights speak eloquently for the vigorous huntress, and I never wearied of watching how swiftly and easily she resumed her flight, and rose out of sight with the game between her feet when approached too closely. But she did not always fly away, and then, though it was difficult to do so, and yet avoid hurting her, I would make her drop the prey by worrying and upsetting her with a straw. Then I would take possession of the victim, and the *Cerceris*, thus despoiled, would hunt about, go into her hole for a moment, come out, and resume the chase. In less than ten minutes the sharp-sighted insect would find a new victim, murder it and carry it off, not seldom to my profit. Eight times running have I stolen from the same individual; eight times did the indefatigable *Cerceris* resume her fruitless journey. Her perseverance tired out mine, and I let her keep the ninth capture.

By this means, and by breaking open cells already filled with provisions, I got nearly a hundred weevils, and in spite of what I had a right to

expect from what Léon Dufour has told us of the habits of the *Cerceris bupresticida*, I could not repress my astonishment at the sight of the singular collection which I had made. His *Cerceris*, though it limits itself to one genus, yet takes any species within that limit, but the more exclusive *C. tuberculata* preys exclusively on *Cleonus ophthalmicus*. On looking through my booty I met with but one single exception, and that belonged to a closely allied species, *C. alternans*—one which I never met with again in my frequent visits to the *Cerceris*. Later researches furnished me with a second exception, *Bothynoderes albidus*, and these are all. Can a specially succulent and savoury prey explain this predilection for a single species? Do the larvæ find in this unvaried diet juices which suit them peculiarly, and which they would not find elsewhere? I do not think so, and if Léon Dufour's *Cerceris* hunted all the kinds of Buprestids, no doubt it was because they all have the same nutritive properties. But this must generally be the case with all the Curculionidæ; their alimentary properties must be identical, and in that case this amazing choice can only be one of size, and therefore of economy of labour and time. Our *Cerceris*, the giant of its race, chooses *C. ophthalmicus* as the largest in our district, and perhaps the commonest. But if this favourite prey fail, it must fall back upon other species, even if smaller, as is proved by the two exceptions above mentioned.

Moreover, it is by no means the only one to hunt the long-nosed class of weevils. Many other *Cerceris*, according to their size, strength, and the

chances of the chase, capture Curculionidæ most various in genus, species, shape, and size. It has long been known that *Cerceris arenaria* feeds her young with similar food. I myself have found in its burrows *Sitona lineata*, *S. tibialis*, *Cneorhinus hispidus*, *Brachyderes gracilis*, *Geonemus flabellipes*, *Otiorhynchus maleficus*. *Cerceris aurita* is known to prey on *Otiorhynchus raucus* and *Phytonomus punctatus*. In the larder of *Cerceris ferreri* I saw *Phytonomus murinus*, *P. punctatus*, *Sitona lineata*, *Cneorhinus hispidus*, *Rhynchites betuleti*. This weevil, which rolls up vine leaves into the shape of cigars, is sometimes of a superb metallic blue, but more usually of a splendid golden copper. I have found as many as seven of these brilliant insects laid up in one cell, and the gorgeous colours of the little heap might almost bear comparison with the jewels buried by the huntress of the Buprestids. Other species, especially the weaker, hunt smaller game, the lesser size being compensated by numbers. Thus, *Cerceris quadricincta* heaps in each cell some thirty *Apion gravidum*, but does not disdain on occasion bigger weevils, such as *Sitona lineata*, *Phytonomus murinus*. *Cerceris labiata* also lays up small species. Finally, the smallest *Cerceris* in my part of France, *C. julii*, hunts the least weevils, *Apion gravidum* and *Bruchus granarius*, game proportioned to its own size. To end this list of provender, let us add that some *Cerceris* follow other gastronomic laws, and bring up their families on Hymenoptera. Such is *C. ornata*. These tastes being alien to our subject, let us pass on.

We see that out of eight species of *Cerceris*

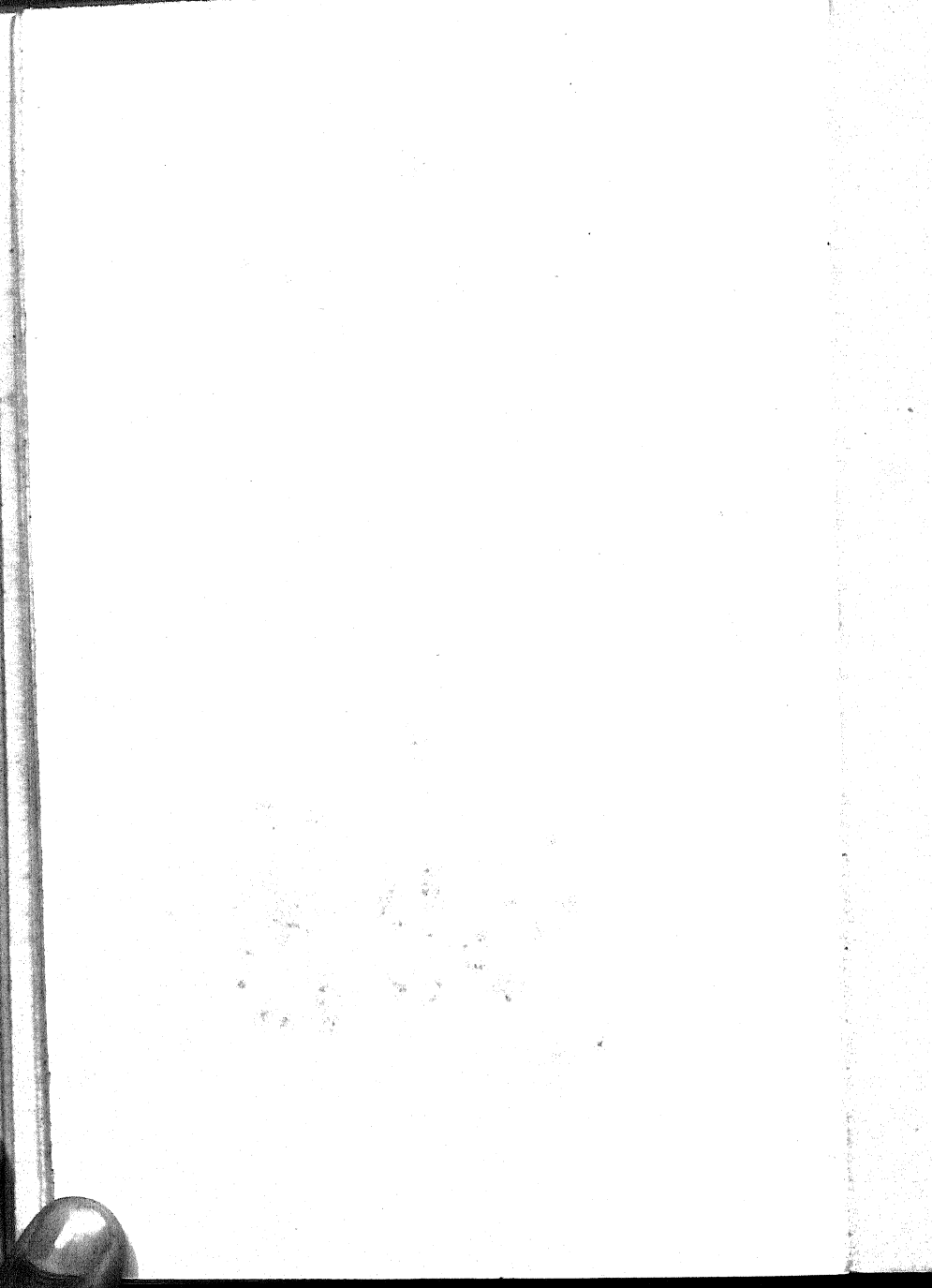
which lay up Coleoptera as food, seven hunt weevils and one Buprestids. What singular reason confines the chase of these Hymenoptera within such narrow limits? What are the motives of such an exclusive selection? What internal likeness is there between the Buprestids and the weevils, outwardly quite dissimilar, that both should become food for carnivorous and nearly related larvæ? No doubt between such and such a victim there are differences as to taste and nutritive qualities which the larvæ thoroughly appreciate, but there must be a far graver reason than these gastronomic considerations to explain these strange predilections.

After all that has been so admirably said by Léon Dufour on the long and marvellous preservation of the insects destined as food for the carnivorous larvæ, it is needless to say that the weevils which I dug up, as well as those taken from between the feet of their murderer, were perfectly fresh, though permanently motionless. Freshness of colour, suppleness of the membranes and smallest articulations, normal condition of the viscera, all combine to make one doubt whether the inert body under one's eyes can really be a corpse, all the more that even under the magnifying glass it is impossible to perceive the smallest wound; and in spite of one's self one expects every moment to see the insect move and walk. Yet more, in weather so hot that insects which had died naturally would in a few hours have become dried up and crumbly, or again in damp weather which would with equal rapidity have made them decay and grow mouldy. I have kept specimens in glass tubes or cones of paper over a month with no precautions, and wonder-



CERCERIS FERRERI AND ITS PREY, THE WEEVIL ;
Rhynchites betulæ on birch leaves, showing two leaves rolled up by the weevil

[To face p. 58.]



ful to say, after all this length of time, the intestines were as fresh as ever, and I found dissection as easy as if the creatures were alive. No, in presence of such facts one cannot talk of an antiseptic, and believe in real death; life is still there—life latent and passive—vegetative life. It alone, struggling successfully for a time against the destructive invasion of chemical forces, can thus preserve the organism from decomposition. Life is still there, but without motion, and we have under our eyes such a marvel as chloroform or ether might produce—a marvel caused by the mysterious laws of the nervous system.

The functions of this vegetative life are slackened and troubled no doubt, but still they are feebly exercised. I have the proof of this in that action of the viscera which takes place normally and at intervals in the weevils during the first week of that deep slumber, which will never be broken, and yet which is not death. It only ceases when the intestine is empty, as is shown by autopsy. But the faint rays of life which the creature manifests do not stop there; and though sensation appears annihilated for ever, I have succeeded in reawakening some vestige of them. Having placed weevils, recently exhumed and absolutely motionless, in a bottle with sawdust moistened with benzine, I was not a little surprised to see a quarter of an hour later moving antennæ and feet. For a moment I thought I could recall them to life. Vain hope! these movements, last trace of a sensitiveness about to cease, soon stopped, and could not be excited a second time. I have repeated this experiment from

some hours to several days after the murder, and always with the same success; only movement is tardy in appearing in proportion as the date of the victim's death is distant. The movements are always from the forepart backward. First, the antennæ move, then the front tarsi tremble and share in the oscillations; next, the second pair do the same; and finally, the third. Once movement is excited, all these members oscillate without any order until all become again motionless, as they do sooner or later. Unless death has been quite recent, movement does not go beyond the tarsi, and the legs remain motionless.

Ten days after the murder I could not obtain the least sign of irritability by the proceeding described, and I had recourse to the Voltaic battery. This is more effective, and provokes muscular contractions where the vapour of benzine fails. One or two elements of Bunsen suffice, which are armed with the rheophores of slender needles. Plunging the point of the one under the furthest ring of the abdomen, and the point of the other under the neck, you obtain each time that the current is established, not only the quivering of the tarsi, but a strong flexion of the feet, which fold themselves under the body, and relax when the current is interrupted. These movements, very energetic during the first days, gradually lose intensity, and after a certain time appear no more. On the tenth day I have still been able to obtain visible motions, but on the fifteenth the pile was unable to provoke them, notwithstanding the suppleness of the limbs and freshness of the viscera. I have submitted also

to the action of the pile Coleoptera really dead, Blaps, Saperda, Lamia, asphyxiated by benzine or sulphureous gas, and two hours later it was impossible to provoke the movements obtained so easily from weevils lying already for several days in the singular state, intermediate between life and death, into which their redoubtable enemy plunges them.

All these facts contradict the supposition of an animal completely dead, and the hypothesis of a real corpse rendered incorruptible by some antiseptic liquid. One can only explain them by admitting that the animal is struck in the principle of its movements, and that sensitiveness, suddenly benumbed, dies slowly out, while the more tenacious, vegetative functions die yet more slowly and preserve the intestines during the time necessary for the larva.

The most important detail to show was how the murder is committed. Evidently, the chief part must be played by the poisoned dart of the Cerceris. But where and how does it penetrate the body of the weevil, covered with a hard cuirass, with pieces so closely joined? Even under the magnifying glass nothing told where the sting entered. Direct examination, therefore, was required to discover the murderous ways of the Cerceris—a problem before whose difficulties Léon Dufour had already recoiled, and the solution of which seemed to me for a time impossible. I tried, however, and had the satisfaction of succeeding, though not without some groping about.

When they fly from their holes to the chase, the Cerceris go here and there, sometimes on one

side, sometimes on the other, and return from all directions, loaded with prey, so that they must seek it on all sides; but as they barely take ten minutes between going and returning, the space worked over could not be very great, especially considering the time necessary to discover the prey, to attack and render it an inert mass. I, therefore, set myself to examine all the adjacent ground with close attention, hoping to discover some *Cerceris* on the hunt. One afternoon devoted to this weary work convinced me of the uselessness of my researches, and of the little chance I had of surprising any of the few *Cerceris*, scattered here and there, and soon lost to view by their rapid flight; above all, in difficult ground, planted with olives, I gave up the attempt. But by carrying live weevils to the neighbourhood of the nests might I not tempt the *Cerceris* by a prey found without trouble, and so observe the drama? The notion seemed good, and the very next day I set out to find live *Cleonus ophthalmicus*. Vineyards, wheat-fields, and crops of lucerne, and heaps of stones did I visit and examine one and all, and after two days of close search I possessed—dare I own it?—three weevils! bare, dusty, maimed of antennæ or tarsi, shabby old creatures which, perhaps, the *Cerceris* would not touch! Since the day of that fevered search, when, for a weevil's sake, I bathed myself in perspiration during my wild expedition, many a year has passed, and yet, in spite of almost daily entomological researches, I am still ignorant of the life and habits of this *Cleonus*, which I met here and there, straying on the edge of paths. Wonderful powers of instinct!

in the same spots, and in a fraction of time, one Hymenopteron would have found hundreds of these insects which man cannot find, and found them fresh and shining, no doubt just emerged from the cocoon !

No matter ; let us experiment with my wretched victim. A *Cerceris* has just gone into her gallery with her prey ; before she comes out for a new expedition I place a weevil a few inches from her hole. The weevil moves about ; when it strays too far I bring it back to its place. At last the *Cerceris* shows her wide face at the mouth of her hole ; my heart beats fast. She walks for a few minutes near her dwelling, sees the weevil, brushes against it, turns, passes several times over its back, and flies off without even honouring my captive with a bite—my captive which cost me so much labour ! I was confounded—knocked over. New attempts at other holes, new disappointments. Decidedly these dainty hunters will have none of the game which I offer them. Perhaps they find it too old, too tasteless ; perhaps, in handling it, I communicated some smell to it which displeases them. Foreign contact disgusts these connoisseurs.

Should I be more fortunate if I obliged the *Cerceris* to defend herself ? I enclosed one with a *Cleonus* in a bottle, irritating them by shaking it. The Hymenopteron, sensitive by nature, was more impressed than the other prisoner, with its dull, heavy organisation ; she thought of escape, not attack. Their parts were exchanged ; the weevil became the aggressor, sometimes seizing with the end of its trunk a foot of its mortal foe, who made

no attempt at defence, so terrified was she. I could devise nothing more; my desire to be present at the *dénouement* had only added to former difficulties. Well, let us try again.

A luminous idea flashed upon me, bringing hope, so naturally did it touch the very heart of the question. Of course, it was the right thing and must succeed. My disdained game must be offered to the *Cerceris* in the heat of the chase—then, absorbed and preoccupied, she will not discover its imperfections. I have already said that on returning from the chase the *Cerceris* alights at the foot of the incline at some distance from the hole, whither she laboriously drags the prey. What I then had to do was to deprive her of her victim, drawing it away by one foot with pincers, and instantly throwing her the living weevil in exchange. This manœuvre succeeded perfectly. As soon as the *Cerceris* felt the prey slip under her body and escape her, she stamped with impatience, turned round, and perceiving the weevil which had replaced hers, flung herself upon it and clasped it in order to carry it away. But she promptly perceived that this prey was alive, and then the drama began and ended with inconceivable rapidity. The *Cerceris* faced her victim, seized its proboscis with her powerful jaws and grasped it vigorously, and while the weevil reared itself up, pressed her forefeet hard on its back as if to force open some ventral articulation. Then the tail of the murderess slid under the *Cleonus*, curved and darted its poisoned lancet swiftly two or three times at the joining of the prothorax, between the first and second pair of feet. In a twinkling all was over. Without

one convulsive movement, with no motion of the limbs such as accompany the death of an animal, the victim fell motionless for ever, as if annihilated. It was at once wonderful and terrible in its rapidity. Then the assassin turned the Weevil on its back, placing herself body to body with it, her legs on either side of it, and flew off. Three times I renewed the experiment with my three Weevils, and the same scene was always enacted.

Of course, each time I gave the *Cerceris* back her first prey and withdrew my *Cleonus* to examine it at greater leisure. This examination only confirmed my opinion of the terrible skill of the assassin. It is impossible to find the slightest trace of a wound, or the smallest flow of vital liquids from the point which was struck. But the most striking thing is the rapid, complete annihilation of all movement. Vainly did I seek even immediately after the murder for any trace of sensibility in the three Weevils done to death under my eyes—neither pinching nor pricking provoked it; to do so required the artificial means already mentioned. Thus these robust *Cleonus*, which, pierced alive with a pin and fixed by a collector on his fatal sheet of cork, would have struggled for days, weeks, nay, whole months, instantly lose all power of motion from the effect of a little prick which inoculates them with a minute drop of poison. Chemistry knows none so active in so small a dose; scarcely could prussic acid produce such an effect, if, indeed, it could do so at all. It is not then to toxology, but to physiology and anatomy that we must turn to find the cause of such instantaneous catalepsy; it is not so much

the great virulence of the poison injected, as the importance of the organ injured by it which we must consider in order to explain these marvels. What, then, is found at the point where the sting penetrates?

V

ONE SKILFUL TO SLAY

THE Hymenopteron has partly revealed her secret by showing us where the sting strikes. But does that explain the question? Not yet, by any means. Let us retrace our steps, forget for a moment what the insect has taught us, and consider the problem set before the *Cerceris*. The problem is this: to lay up in an underground cell a certain number of heads of game which may suffice to nourish the larva hatched from the egg laid upon the heap of provender.

At first sight this storing of food appears simple enough, but reflexion soon discovers graver difficulties. Our own game is brought down by a shot and killed with horrible wounds. The Hymenopteron has refinements unknown to us; she chooses to have her prey intact, with all its elegance of form and colour. No broken limbs, no gaping wounds, no hideous disembowelment. Her prey has all the freshness of the living insect; she does not destroy an atom of the fine-coloured powder which the mere contact of our fingers deflowers. If the insect were really dead, really a corpse, how difficult it would be for us to obtain such a result! Any one can slay

an insect by stamping brutally on it, but to kill it neatly leaving no sign is no easy operation, within every one's power. How many of us would be at our wits' end if we had to kill on the spot, without crushing it, a little creature so tenacious of life that even beheaded it still goes on struggling! One must have been a practical entomologist before thinking of asphyxiation, and here, again, success would be doubtful with the primitive methods of vapour of benzine or burnt sulphur. In this deleterious atmosphere the insect struggles too long, and tarnishes its brightness. One must have recourse to more heroic methods—for instance, to the terrible exhalations of prussic acid slowly disengaging themselves from strips of paper impregnated with cyanide of potassium, or better still, as being without danger to the collector, to the thunderbolt of vapour of bisulphide of carbon. It requires a real art, an art calling to its aid the redoubtable arsenal of chemistry, to kill an insect neatly; to do that is what the elegant method of the *Cerceris* brings about so quickly, if we admit the stupid supposition that her prey really becomes a dead body.

A dead body! But that is by no means the diet of the larvæ, little ogres greedy for fresh meat, to whom game ever so slightly tainted would inspire insurmountable disgust. They must have fresh meat with no high taste—that first sign of decay. Yet the prey cannot be laid up alive in the cell like animals destined to furnish fresh meat to the crew and passengers of a vessel. What would become of a delicate egg laid among living food? What would become of the feeble larva, a worm bruised by the slightest

thing among vigorous Coleoptera moving their long spurred legs for whole weeks? It is absolutely necessary—and here we seem caught in a blind alley—to obtain deathly immobility with the freshness of life for the interior organs. Before such an alimentary problem the best instructed man of the world would stand helpless—even the practised entomologist would own himself at a loss. The larder of the *Cerceris* would defy their reasoning powers.

Let us then imagine an academy of entomologists and physiologists, a congress where the question should be discussed by Flourens, Majendies, Claude Bernards. To obtain at once complete immobility and long preservation of food, the first and most natural and simple idea would be that of preserved meats. One would invoke some antiseptic liquid, as the illustrious savant of the Landes did with regard to his Buprestids, and attribute such virtue to the poisonous fluid of the *Cerceris*, but this strange quality has yet to be proved. Gratuitous hypothesis replacing the unknown quantity of the preserving liquid may perhaps be the final verdict of the learned assembly, as it was that of the naturalist of the Landes.

Should one insist and explain that the larvæ require not preserved food which could never have the properties of flesh still palpitating, but prey yet alive, so to say, in spite of complete absence of motion, the learned Congress, after ripe consideration, will fall back upon paralysis: "Yes, of course; the creature has to be paralysed without being killed." There is but one means of arriving at this

result, namely, to injure, cut, and destroy the nervous system of the insect in one or more skilfully chosen points.

If the question be thus left in hands unfamiliar with the secrets of a delicate anatomy it will not have advanced far. What is the arrangement of this nervous system which must be paralysed without killing the insect? First, where is it? In the head no doubt and along the back, like the brain and spinal marrow in the superior animals. "A grave mistake!" our congress would reply; the insect is so to say an animal reversed, which walks on its back—that is, it has the spinal marrow below instead of above, all along breast and stomach; therefore on the lower surface alone can the operation to paralyse the insect be performed.

This difficulty removed, a far graver one presents itself. Armed with his scalpel, the anatomist can direct its point where he will in spite of obstacles which he may have to set aside. The Hymenopteron has no choice. Its victim is a solidly cuirassed beetle, its lancet a dart, extremely delicate, which the horny mail would certainly turn aside. Only certain points are vulnerable to the frail tool, namely, the joints, protected simply by a membrane with no power of resistance. But the joints of the limbs, although vulnerable, do not in the least fulfil the necessary conditions, for through these the utmost that could be obtained is local paralysis, not one affecting the whole organism of motion. Without any prolonged struggle, without repeated operations, which, if too numerous, might endanger the victim's life, the Hymenopteron has, if possible, to abolish all

motive power at one blow. Therefore she must direct her dart at the nervous centres, the source of the power of motion whence radiate the nerves running up to the various organs of movement. Now these sources of locomotion, these nervous centres, consist of a certain number of ganglia, more numerous in the larva, less so in the perfect insect, and arranged on the median line of the under surface in a string of beads more or less distant and connected by a double ribbon of nervous tissue. In all insects which have reached the perfect state the ganglia called thoracic, *i.e.* those furnishing nerves to wings and feet and governing their movements, are three in number. Here are the points to be struck: if their action can be in any way destroyed, the possibility of movement is destroyed also.

Two ways of reaching these motive centres offer themselves to the feeble dart of the Hymenopteron; one, the joint between neck and corslet; the other the spot where the latter joins the continuation of the thorax, between the first and second pair of feet. The way through the neck does not answer; it is too far from the ganglia, which lie near the base of the feet which they animate. The blow must be dealt at the other spot, and through that only. Thus would an academy decide where Claude Bernards illuminated the question by their profound science. And it is precisely there, between the first and second pairs of feet on the median line of the under surface, that the *Cerceris* plunges her lancet. By what learned intelligence must she be inspired!

To choose as the spot in which to plant her sting the one vulnerable point, the point which only a

physiologist versed in the anatomy of insects could determine beforehand is by no means enough ; the Hymenopteron has a far greater difficulty to overcome, and she overcomes it with a mastery which fills one with amazement. We said that the nervous centres controlling the organs of motion in an insect are three. These are more or less distant from each other, but sometimes, though rarely, near together. They possess a certain independence of action, so that an injury to one does not cause, at all events immediately, more than paralysis of members connected with it, while the other ganglia and their corresponding members are not affected by it. To reach these three sources of motion one after the other, the second farther off than the first, and the last farther still, and by a single way, between the first and second pairs of feet, seems impossible for the sting, which is too short, and besides, so difficult to aim well in such conditions. True, certain Coleoptera have the three ganglia of the thorax almost touching, and others have the two last completely united, soldered, smelted together. It is also recognised that in proportion as the different nervous centres combine and centralise, the characteristic functions of animality become more perfect, and also, alas, more vulnerable. Those Coleoptera with centres of motion so near that they touch or even gather into one mass, and so are made part of each other, would be instantly paralysed by one sting ; or if several were needed, at all events the ganglia to be paralysed are all collected under the point of the dart.

Now which are the Coleoptera so specially easy

to paralyse? That is the question. The lofty science of a Claude Bernard, floating in the fundamental generalities of organisation and life, is no longer enough for us; it is unable to inform and guide us in this entomological selection. I appeal to every physiologist under whose eye these lines may fall. Without having recourse to his bookshelves, could he name the Coleoptera where such a nervous centralisation is found, and even with the help of his library, could he instantly lay his hand on the information wanted? The truth is, we are entering on the minute details of the specialist; the highway is quitted for a path known to few.

I find the necessary documents in the fine work of M. E. Blanchard (*Annales des Sciences Naturelles*, 3me série, tome v.) on the nervous system of Coleoptera. There I find that this centralisation of nerve power belongs especially to the Scarabæus, but most of these are too large; the *Cerceris* could neither attack nor carry them away; besides, many live in filth, where the cleanly Hymenopteron could not go to seek them. Motive centres very close together are also found among the Histers, which live on impurity, amid the smell of decay, and again that will not do; also in the *Scolytus*, which is too small, and finally in Buprestids and Weevils.

What unexpected light amid the pristine obscurities of the problem! Amid the immense number of the Coleoptera which the *Cerceris* seem able to prey upon, two groups alone, Weevils and Buprestids, fulfil the indispensable conditions. They live far from decay and dung, which perhaps cause invincible repugnance in this dainty *Cerceris*; they are

of most varied size, proportioned to that of their different captors, which may thus choose according to their convenience. They are far more vulnerable than all the others at the one point where the sting of the Hymenopteron can penetrate successfully, for at that point, all easily accessible to the dart, crowd the motor centres of feet and wings. At this point the three thoracic ganglia of Weevils lie very close, the hind two are contiguous. At that same spot in the Buprestids the second and third are welded in one large mass a little distance from the first. And as it is precisely Buprestids and Weevils which are hunted, to the absolute exclusion of all other game, by the eight species of *Cerceris*, whose food stores of Coleoptera have been ascertained, a certain internal likeness, namely, in centralisation of the nervous system must be the explanation why there are heaped in the dens of various *Cerceris* victims, outwardly so unlike.

In this choice, upon which even transcendent knowledge could not improve, such an assembly of difficulties is splendidly resolved, that one asks if one be not the dupe of some involuntary illusion, and if preconceived theories have not obscured the reality of facts, in short, whether the pen has not described imaginary marvels. A scientific result is only solidly established when confirmed by experiments repeated in every possible way. Now let us submit to experimental proof the physiological operation taught us by *Cerceris tuberculata*. If it be possible to obtain artificially what the Hymenopteron obtained by her sting, *i.e.* abolition of movement, and long preservation of the victim in a

state of perfect freshness; if it be possible to bring about this wonder with the Coleoptera hunted by the *Cerceris*, or with those possessing a like nervous centralisation, while one fails with those whose ganglia are far apart, one must admit, however exacting one may be in the matter of proof, that the Hymenopteron possesses in the unconscious inspirations of instinct the resources of sublime science. Let us see then what experiment shows. The manner of operation is very simple. With a needle, or, better still, with the point of a fine steel pen, we must introduce a tiny drop of some corrosive liquid into the thoracic motive centres, pricking the insect slightly at the jointing of the prothorax behind the first pair of feet. The liquid which I use is ammonia, but it is evident that any other liquid whose action is equally strong would produce the same results. The metal pen being charged with ammonia as it might be with a droplet of ink, I give the prick. The effects thus obtained differ enormously, according to whether the experiment be made upon species with thoracic ganglia near together or upon those where these same ganglia are far apart. With regard to the first category, my experiments were made on *Scarabæus*, *S. sacer* and *S. longicollis*; on a bronze *Buprestis*; and on weevils, especially that *Cleonus* hunted by the heroine of these observations. In the second category I have experimented on *Caraboidea*, *Carabus*, *Procrustes*, *Chloenius*, *Sphodrus*, *Nebria*; *Longicornia*, *Saperda*, and *Lamia*; on *Melasomes*; *Blaps*, *Scaurus*, and *Asida*.

Among the *Scarabæus* class, the *Buprestids*, and the

Weevils, the effect is instantaneous. Every movement stops suddenly, without any convulsion, as soon as the fatal drop has touched the nerve centres. The sting of the *Cerceris* does not produce prompter extinction. Nothing can be more striking than this sudden immobility in a vigorous *Scarabæus sacer*, but the likeness between the effects produced by the dart of the *Cerceris* and the steel pen charged with ammonia does not stop here. *Scarabæids*, *Buprestids*, and Weevils artificially stung, in spite of their complete immobility, preserve for three weeks, one month, or even two, the perfect flexibility of every joint and the normal freshness of the interior organs. With them defecation takes place on the first days as in the normal condition, and movement can be excited by the Voltaic current. In a word, they behave exactly as do *Coleoptera* sacrificed by the *Cerceris*. There is complete identity between the state into which she plunges her victims and that produced at will by injecting ammonia into the nerve centres of the thorax. Now, as it is impossible to attribute the perfect preservation of the insect during so long a time to the drop injected, one must altogether reject the notion of an antiseptic fluid, and grant that in spite of utter immobility the creature is not really dead. A spark of life exists, keeping the organs for some time in normal freshness, but dying out by degrees and leaving them at last subject to corruption. Moreover, the ammonia in some cases produces extinction of movement in the feet only, and then the deleterious action of the fluid having doubtless not extended far enough, the antennæ preserve some mobility,

and one sees that the creature, even a month after inoculation, draws them back quickly at the least touch—an evident proof that life has not completely abandoned the inert body. This movement is not rare with Weevils wounded by the *Cerceris*.

Injection of ammonia always stops motion at once in Buprestids, Weevils, and Scarabæus, but it is not always possible to put the creature into the state just described. If the wound be too deep, or the little drop instilled be too strong, at the end of two or three days the victim really dies, and after two or three days there is but a decaying body. If, on the contrary, the prick be too slight, it recovers the power of motion, at least partially, after being inanimate for more or less time. The *Cerceris* herself may operate clumsily, just like man, for I have seen this kind of resurrection in a victim struck by the dart of a Hymenopteron. *Sphex flavipennis*, whose history will presently occupy us, heaps in her dens young crickets struck by her venomed lancet. From one of her holes I have taken three poor crickets whose extreme flabbiness would, in any other circumstances, have denoted death. But here, again, death was only apparent. Placed in a bottle, these crickets kept quite fresh but motionless for nearly three weeks, after which two grew mouldy, while the third came partly to life—that is to say, it regained motion of the antennæ, mouth-parts, and, which is more remarkable, of the first two pairs of feet. If even the skill of the Hymenopteron sometimes fails to benumb a victim for good and all, can one expect constant success with the rough experiments of man?

In Coleoptera of the second category—those where the ganglia of the thorax are distant one from another—the effect of ammonia is quite different. Those which show themselves least vulnerable are the Caraboidea. A puncture which would instantly have annihilated motion in the large *Scarabæus sacer*, in the middle size Caraboidea only causes violent, disordered convulsions. By degrees the creature quiets down, and after some hours' rest resumes its habitual movements as if nothing had happened to it. If the experiment be repeated on it twice, thrice, even four times, the results are the same, until the wound becomes too serious, and it dies outright, as is proved by the drying up and putrefaction which soon follow.

The Melasomes and the Longicorns are more sensitive to the action of ammonia. The injection of a small corrosive drop quickly renders them motionless, and after some twitching they seem dead. But the paralysis which would have persisted in Weevils, Scarabids, and Buprestids is but momentary. Before long motion reappears as energetic as before. It is only when the dose of ammonia is of a certain strength that movement does not reappear. But then the creature is really dead, and putrefaction rapidly comes on. It is then impossible to cause complete and persistent paralysis in Coleoptera with ganglia far apart by the means so efficacious in those with ganglia near together. At the utmost one can only obtain momentary paralysis, which passes quickly away. The demonstration is decisive. *Cerceris* which prey on Coleoptera conform in their

choice to what the most learned physiology and finest anatomy alone can teach. It would be vain to endeavour to see nothing here but chance agreement; it is not chance which explains such harmony.

VI

THE YELLOW-WINGED SPHEX

IN their impenetrable coat of mail the Coleoptera offer but one vulnerable point to their dart-bearing foe. This defect in the cuirass is known to the assassin, and the poisoned sting is there inserted, striking at one blow the three centres of motion, the Weevil and Buprestid, which alone have a nervous organisation sufficiently centralised, being selected. But what happens when the insect wears no armour and is soft-skinned, so that the Hymenopteron can pierce it anywhere that the chances of the struggle may direct? Is there then a choice as to where the blow is given? Like the assassin who strikes at the heart to shorten the dangerous struggles of his victim, does the Sphex follow the tactics of the *Cerceris*, and strike by preference at the motor ganglia? If so, what happens when these are distant from one another, acting so independently that paralysis of one does not affect the others? These questions will be answered by the history of an insect which hunts field crickets, *Sphex flavipennis*.

It is towards the end of July that this Sphex

tears open the cocoon which until then has protected it, and flies away from its subterranean cradle. During the whole of August one constantly sees it seeking drops of honey on the spiny heads of *Eryngium campestre*, the commonest of such robust plants as brave the dog days. But this careless life is brief, for in the earliest days of September the SpheX has begun the hard existence of miner and hunter. It is usually on some small flat spot on banks along a road that the dwelling is established, only there must be two indispensable conditions—a sandy soil easy to work, and sun. Beyond this no precaution is taken to shelter the domicile against autumn rain and winter frost. A horizontal position, unsheltered, beaten by rain and wind, suit the SpheX perfectly, so long as it is exposed to the sun. But when the work is half-way through, if heavy rain should come, it is sad to see next day galleries in course of construction choked with sand and finally abandoned.

Rarely does the SpheX work in solitude; it is in small bands of ten, twenty, or more excavators that the claim selected is worked. One must have spent some days watching one of these colonies in order to form any idea of the restless activity, the feverish haste, the abrupt movements, of these hard-working miners. They rapidly attack the ground with the rakes of their forefeet, *canis instar*, as Linnaeus says. A puppy does not show more energy in scratching up the ground in play. At the same time each labourer hums a joyous song—shrill, high-pitched, interrupted at short intervals, and modulated by vibrations of wings and thorax. One

would think they were a troop of merry comrades, stimulating one another to work by a cadenced rhythm. Meanwhile, the sand flies, falling in fine dust on their quivering wings, and the heavier gravel, pulled out bit by bit, rolls far away. If a bit resist too much, the insect goes at it with a high note, reminding one of the cry with which a woodcutter accompanies the stroke of his axe. Under the redoubled efforts of tarsi and mandibles the cavity is already sketched out, and the *Sphex* can already dart into it. Then comes a lively interchange of forward movements to detach material, and of backward to brush out fragments. In this hurried coming and going the *Sphex* does not so much walk as dart forward, as though impelled by a spring. With panting abdomen, antennæ vibrating, the whole body moved by a strong thrill, she springs forward and is out of sight. You still hear the unwearied hum underground, and one sees from time to time hind legs pushing backward a wave of sand to the mouth of the burrow. From time to time labour underground is interrupted either that the *Sphex* may dust herself in the sunlight, and get rid of grains of dust which insinuate themselves into delicate joints and hamper the liberty of her movements, or that she make a reconnaissance in the neighbourhood. Notwithstanding these short interruptions, in a few hours the gallery is hollowed out and the *Sphex* appears on her threshold, to voice her triumph, and give the last touch to her labours by effacing some inequality, or carrying away some particles of earth, the objection to which only the eye of a *Sphex* could perceive.

Of the many tribes of Sphegidæ visited by me, there is one of which I retain a specially lively recollection, on account of its singular installation upon the edge of a high road, where were little heaps of mud thrown up from side ditches by the cantonnier's shovel. One, well sun-dried, had a conical shape like a sugar-loaf over fifteen inches high. The situation pleased the Sphegidæ, who had established a more populous community than I have ever again met with. From base to summit the cone of dried mud was pierced with burrows, giving it the appearance of a huge sponge. In every story was feverish animation, and a busy coming and going which brought to mind the scene in some great workshop when orders are pressing. Crickets were being dragged by the antennæ up the slopes of the conical city; there was storing of provisions in the larders of the cells; dust was pouring from galleries in process of construction; at intervals the grimy faces of the miners appeared at mouths of passages—there was a constant going and coming. Now and then, in a short interval of leisure, a Sphex ascended the top of the cone, perhaps to take a general and well-satisfied view from this belvedere. What a tempting sight!—one to make me long to carry away the entire city with its inhabitants. It was useless to try; the mass was too heavy. One cannot take up a village by the roots to plant it elsewhere.

Let us look at the Sphex at work in flat ground, as is much more frequently the case. As soon as the burrow is hollowed out, the chase begins. Let us profit by the absence of the Hymenopteron

in search of game, and take a look at her dwelling. The spot chosen by a *Sphex* colony is generally horizontal, though the ground is not so level but that there are little mounds crowned by a tuft of grass or thrift, or inequalities consolidated by the slender roots of the vegetation which covers them. It is on the sides of such furrows that the *Sphex* places her den. For two or three inches in depth the gallery is horizontal, serving as an approach to the hidden shelter for the provender and the larvæ. In this vestibule the *Sphex* takes refuge in bad weather, rests there at night, and occasionally by day for a few instants, showing only her expressive face and impudent eyes. Beyond the vestibule an abrupt turn descends more or less obliquely to a depth of two or three inches more, ending in an oval cell rather larger in diameter, whose axis lies parallel with the horizontal gallery. The cell walls are not covered with any particular cement, but in spite of their bareness they have evidently been the object of most careful labour. The sand is heaped and levelled on the floor, on the ceiling, and sides, so as to do away with the risk of landslips, or any roughness which might injure the delicate skin of the larva. This cell communicates with the passage by a narrow entrance, just wide enough to allow the *Sphex*, burdened with prey, to enter. When this first cell is furnished with an egg and necessary provisions, the *Sphex* walls up the entrance, but does not yet abandon her burrow. A second cell is hollowed beside the first, and provisioned in the same manner; there is then a third made, and sometimes a fourth. Only then does the *Sphex* cast back into the

burrow the rubbish heaped at the entrance, completely effacing all outward trace of her work. Three cells are usually found in each burrow, rarely two, and yet more rarely four. As one learns by dissecting the insect, one may estimate the number of eggs laid at about thirty, which would make the number of burrows needed ten. Now these are hardly begun before September, and are finished before the end of the month. Consequently the *Sphex* cannot devote more than two or three days at most to each burrow and its stores. Evidently the active little creature has not a minute to lose, when in so short a time she has to hollow out the lair, procure a dozen crickets, sometimes brought from a distance through endless difficulties, to store them, and finally to stop up the burrow. Moreover, there are days when wind makes hunting impossible; rainy days or overcast ones suspending all work. The *Sphex* cannot give to her building the enduring solidity that *Cerceris tuberculata* gives to its deep galleries. This species transmit their solid abodes from one generation to another, each year hollowed more deeply, so that I was often bathed in perspiration when I tried to reach them, and frequently my efforts and my implements proved useless. The *Sphex* inherits nothing, and must herself do everything, and that rapidly. Her dwelling is but a tent, hastily erected and moved on the morrow. In compensation the larvæ, covered but by a thin layer of sand, know how to supply the shelter which their mother has not given them; they can clothe themselves with a double and triple waterproof covering, far superior to the thin cocoon of the *Cerceris*.

But here comes a *Sphex* with noisy hum, returning from the chase. She pauses on a neighbouring bush, holding in her mandibles one of the antennæ of a big cricket, weighing far more than herself. Tired out by the weight, she rests a moment, then grasps her captive between her feet, and with a supreme effort flies right across the ravine between her and her abode. She alights heavily on the flat ground where I am watching, in the very middle of a *Sphex* village. The rest of the journey is made on foot, the *Sphex*, not in the least intimidated by my presence, comes astride her victim, holding her head proudly aloft while she drags along the cricket between her feet by one of its antennæ held in her jaws. If the soil be bare there is no difficulty, but should a network of grass spread its runners across the way, it is curious to see the astonishment of the *Sphex* at finding her efforts baffled by this little obstacle—curious to witness her marches and countermarches and repeated attempts until the difficulty is surmounted either by the aid of her wings or a well-planned *détour*. The cricket is at last conveyed to its destination and placed so that its antennæ come exactly to the mouth of the burrow. Then the *Sphex* abandons it and descends in haste to the bottom of the cave. A few seconds later she puts her head out with a little cry of joy. The antennæ of the cricket are within reach; she seizes them and promptly conveys it down to her den.

I still ask myself in vain why these complicated manœuvres at the moment of conveying the cricket into the burrow. Why, instead of going down

alone and returning to resume the prey left on the threshold, does not the Spheg drag it into the gallery, as she did in the open air, since the space is wide enough, or take it with her while she enters backwards? The various predatory Hymenoptera which I have been able to observe all drag their prey at once to the bottom of their cells, holding it underneath them by their mandibles and intermediary feet. Léon Dufour's *Cerceris* does indeed somewhat complicate her movements, since after putting down her *Buprestis* for a moment at the door of her underground abode, she instantly goes backward into the gallery, seizes her victim with her mandibles and drags it down; but that is very unlike the tactics adopted in a like case by the Spheg. Why this domiciliary visit, which invariably precedes the introduction of the prey? May it not be that before descending hampered by a load, the Spheg thinks it prudent to give a look round the bottom of her dwelling to make sure that all is in order and to drive out, if necessary, some impertinent parasite which may have slipped in during her absence? Several *Diptera*, predatory flies, especially *Tachinidæ*, watch at the doors of all the hunting Hymenoptera, spying out the favourable moment to lay their eggs on other people's game, but none penetrate into the dwelling, nor venture into the dark passages, where, if by ill-luck the owner caught them, they might have to pay dearly for their audacity. The Spheg, like others, pays her tribute to the predatory *Tachinidæ*, but they never enter her burrow to commit their misdeeds. Besides, have they not all the time they need to lay their eggs on the cricket?

If they look sharp, they may very well profit by the *Sphex*'s momentary absence from her victim to confide their posterity to it. What yet greater danger menaces the *Sphex* which renders this preliminary descent to the bottom of the burrow such an imperious necessity?

The one observed fact which can throw any light on the problem is this. Amid a colony of *Sphegidae* in full activity, whence all other Hymenoptera are habitually excluded, I one day surprised a sportsman of a different kind, *Tachytes nigra*, carrying one by one, without any haste and with the greatest composure, amid the crowd where he was but an intruder, grains of sand, little bits of dry stalk, and other small materials, to stop up a burrow of the same shape and size as the neighbouring ones of the *Sphegidae*. This labour was pursued too conscientiously to admit of any doubt as to the presence of the worker's egg in the underground dwelling. A *Sphex* with anxious movements, apparently the legitimate owner of the burrow, never failed each time that the *Tachytes* entered the gallery to dart in pursuit, but emerged swiftly, as if frightened, followed by the other, who continued her task unmoved. I visited this burrow, the evident cause of strife between them, and found a cell provisioned with four crickets. Suspicion almost gave place to certainty, for this allowance far exceeded the needs of a *Tachytes*' larva, which is at least one-half smaller than the *Sphex*. The calm insect whose care to stop up the burrow at first suggested that it was the owner was really a usurper. How comes it that the *Sphex*, larger and

more robust than her adversary, allows herself to be robbed with impunity, limiting herself to a fruitless pursuit, and flying like a coward when the intruder, who seems not even to perceive her, turns round to come out of the burrow? Is it with insects as with men, the first quality needed for success is audacity—audacity—audacity? Certainly the usurper had no lack of it. I can still see that Tachytes, imperturbably calm, going and coming before the meek SpheX, which stamped with impatience, but did not venture to fall upon the thief.

Let us add that in other circumstances I have repeatedly found this Hymenopteron, I suppose to be a parasite—this *Tachytes nigra*, dragging a cricket by one of its antennæ. Was it a prey lawfully acquired? I would fain think so, but the indecision of the insect which strayed about the ruts in the paths as if seeking a convenient burrow always left me suspicious. I have never been present when it burrowed, if indeed it ever does undertake that labour, and what is more, I have seen it abandon its game to decay, perhaps not knowing what to do with it for want of a hole where to put it. Such wastefulness seems to indicate goods ill-gotten, and I ask myself if the cricket were not stolen when the SpheX left it on her threshold? I also suspect *Tachytes obsoleta*, banded with white round the abdomen like *SpheX albisecta*, which nourishes its larvæ with crickets such as are hunted by the latter. I have never seen it digging galleries, but I have caught it dragging crickets that the SpheX would not have disdained. This similarity of food in species of different genera makes me doubtful whether the

booty were lawfully come by. Let me add, however, to atone in some measure for the injury which my suspicions may do to the character of the genus, that I have seen the perfectly lawful capture of a little cricket yet wingless by *Tachytes tarsina*, and have also seen it hollow cells and store them with prey bravely acquired. Thus I have only suspicions to offer as to why the *Sphex* persists in descending to the bottom of her hole before carrying in prey. Is there some other end besides that of dislodging a parasite which may have got in during the owner's absence? I despair of finding out; who can interpret the thousand manœuvres of instinct? Poor human reason which cannot even explain the wisdom of a *Sphex*!

At all events, it is proved that these manœuvres are singularly invariable, *à propos* of which I will mention an experiment which greatly interested me. At the moment when the *Sphex* makes her domiciliary visit, I take the cricket and put it some way off. The *Sphex* comes up, utters her usual cry, looks round with astonishment, and seeing the game too far off, comes out to seize and put it in the right position. Then she goes down again without the cricket. Same manœuvre on my part, same disappointment when she reappears. Again the prey is brought to the mouth of the hole, and again the *Sphex* goes down alone, and so on as long as my patience holds out. Forty times on end have I tried the experiment on the same individual; her persistence vanquished mine, and her tactics never varied.

Having proved the inflexible pertinacity of all

the Sphegidæ in one colony on whom I cared to experiment, I could not but perplex myself over it. "Does then the insect obey a fixed tendency which circumstances cannot modify?" I asked myself. "Are its actions all done by rule, and is it unable to acquire the least experience from its own proceedings?" Later observations modified this too absolute judgment.

The following year, at the proper time, I visited the same spot. The new generation had inherited for their burrows the place chosen by the preceding ones; it had also faithfully inherited their tactics, for the cricket experiment gave the same results. Such as were the Sphegidæ of the past year such are those of the present one, equally persistent in a fruitless attempt. My error grew confirmed until good luck brought me to another colony in a different place. I renewed my experiments. After two or three trials with the old, well-known result, the Sphegidæ got astride of the cricket, seized its antennæ with her mandibles, and dragged it at once into the burrow. Who looked a fool then? The experimenter baffled by the clever Hymenopteron. At the other holes her neighbours, some sooner, some later, found me out, and went down with their prey instead of persisting in leaving it on the threshold to seize it later. What is the meaning of this? This colony, descended from another stock, for sons return to the spot selected by their forefathers, is cleverer than the one observed last year. Craft is inherited; there are sharper-witted tribes and duller ones, apparently according to the faculties of their forefathers. With Sphegidæ, as with us, the kind

of intellect changes with the province. Next day I tried the cricket experiment in another locality, and it invariably succeeded. I had come upon a dense-minded tribe, a true colony of Bœotians, as in my earlier observations.